Sutter Basin, California
Pilot Feasibility Study

Progress Document #1:
Without Project & Alternative Development
DRAFT

US Army Corps
of Engineers

Sacramento District

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Progress Document Purpose:

This is a summary document of the progress and process of the Sutter Basin Pilot Feasibility Study up to the development of a Refined Array of Alternatives.

A subsequent progress document will summarize the work and process of the Sutter Basin Pilot Feasibility Study to a Draft Array of Alternatives to a Tentatively Selected Plan.

Sutter Basin Pilot Feasibility Study

Progress #1 Document: Without Project and Alternative Development

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1.0 INTRODUCTION

1.1 PURPOSE AND NEED FOR THE STUDY AND DOCUMENT

A high risk of flooding from levee failure threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding has caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees do not meet U.S. Army Corps of Engineers (USACE) levee design standards, authorized level of performance, and are at risk of breach failure at stages less than overtopping of the levees. Within the study area, as throughout the Sacramento Valley, floodplain and native habitats have been lost or degraded. Federally listed species and other special status species that are dependent on floodplain habitats have declined. Opportunities exist to restore land formerly converted by mining or agriculture to more natural habitats through Ecosystem Restoration (ER) in conjunction with flood risk management (FRM). There are also opportunities to provide outdoor recreational features on FRM and ER project lands. The purpose of the Sutter Basin Feasibility Study is to address FRM in conjunction with ER and recreation.

This document summarizes progress to the determination of the refined array of alternatives on the Sutter Basin Pilot Study. This array of alternatives will be considered in greater detail as the study progresses toward selection of the Tentatively Selected Plan. The information presented in this document will be incorporated into the draft Feasibility Study and Environmental Impact Statement/ Environmental Impact Report (EIS/EIR), which will integrate plan formulation with documentation of environmental effects. The Feasibility Study/EIS/EIR will serve to satisfy documentation requirements of ER 200-2-2 as well as the National Environmental Policy Act (NEPA) of 1969, as amended, and the requirements of the California Environmental Quality Act (CEQA).

1.2 STUDY AUTHORITY

The authority for the U.S. Army Corps of Engineers (USACE) to study FRM and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962 (Public Law 87-874). A portion of the authorization reads as follows:

"The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes…to be made under the direction of the Chief of Engineers, in drainage areas of the United States…, which include the following named localities: Sacramento River Basin and streams in northern California, draining into the Pacific Ocean for the purpose of developing,

where feasible, multi-purpose water resource projects, particularly those which would be eligible under the provision of title III of Public Law 85-500."

The authority for including ecosystem restoration as a study objective or purpose in association with FRM is found in numerous Federal laws and executive orders establishing National policy for and Federal interest in the protection, restoration, conservation and management of environmental resources. These provisions endorse Federal efforts to advance environmental goals, and a number of these general statements declare it national policy that full consideration is given to the opportunities which projects afford to ecological resources. Recent water resources authorizations have specifically or programmatically enhanced opportunities for Corps involvement in addressing objectives related to the restoration of ecological resources and ecosystem management.

The legislative basis for Federal participation in recreation development is found in the Flood Control Act of 1944, as amended, the Federal Water Project Recreation Act of 1965 (Public Law 89-72), and the Water Resources Development Act of 1986 (Public Law 99-662). These give broad authority to include recreation as a project purpose. Present policy limits exercise of these authorities as defined in ER 1105-2-100, Planning Guidance.

1.3 STUDY SPONSORS

The non-Federal project sponsors include the State of California Central Valley Flood Protection Board (CVFPB) and the Sutter Butte Flood Control Agency (SBFCA). SBFCA is a joint powers agency formed in September 2007 by Sutter and Butte Counties, the cities of Biggs, Yuba City, Gridley, Live Oak, and levee districts 1 and 9 to finance and construct regional levee improvement projects.

1.4 LOCATION AND DESCRIPTION OF THE STUDY AREA

The study area is located in Sutter and Butte Counties California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter with a total population of approximately 80,000. Yuba City is the largest community in the study area, with a population of approximately 65,000. A map of the watershed is included as Plate 1 and a map of the study area is included as Plate 2.

The study area is essentially encircled by project levees of the Sacramento River Flood Control Project (Plate 3) and high ground of the Sutter Buttes. In 1917, the Federal government authorized the Sacramento River Flood Control Project (See Plate 3), which adopted a system of locally built levees as Federal levees, and constructed additional levees, bypasses, overflow weirs, and pumping facilities. Although the Sacramento River Flood Control Project levees were often constructed of poor foundation materials such as river dredge soils that would not meet today's engineering standards, the levees are relied upon today to provide FRM for numerous communities.

The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage. Flood depths and

frequency vary throughout the study area. Probability of flooding within the study area is primarily related to the stage of floodwaters within the river channels and the geotechnical probability of levee failure at or below flood stage.

The Butte Basin is a natural overflow and flood storage area north west of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (DWR, 2010). Excess floodwaters from the Sacramento River enter Butte Basin via overbank areas along the river and through the Moulton and Colusa weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is regulated by hydraulic conditions of Butte Slough and floodplain topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

The Sutter Bypass is a leveed flood control structure approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's flood bypass system. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather River to the confluence of the Sacramento River and Yolo Bypass at Fremont Weir. Additional flood flows from the Sacramento River enter the Sutter Bypass through Tisdale Bypass. The lower portion of the Sutter Bypass also conveys the Feather River. Within this reach the Feather River is separated from the main conveyance of the bypass by a low levee. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events. The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass includes four hydrologic reaches determined on tributary inflows; Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, Feather River to Sacramento River.

The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed: Oroville on the Feather River and New Bullards Bar on the Yuba River. The Feather River is described by four hydrologic reaches based on significant inflows; Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

The Cherokee Canal is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south.

The Wadsworth Canal is a leveed tributary to the Sutter Bypass near the town of Sutter. The canal conveys flow from the East and West interceptor canals to the Sutter Bypass. The East and

West interceptor canals collect runoff from canals and shallow floodplain runoff into the Wadsworth Canal.

1.5 RELATED PROJECTS AND STUDIES

1.5.1 Advance Work by Local Interests in Study Area

Sections 104 and 3041 of WRDAs 1986 and 2007, respectively, provide authorization for non-Federal sponsors to receive credit for the cost of local advanced work to be applied to the required local contribution for the project. Section 104 authorizes credit for local work accomplished prior to authorization of the project provided that the Assistant Secretary of the Army for Civil Works has approved the proposed work prior to initiation of construction. Section 3041 authorizes credit for local work accomplished prior to the date of the Project Partnership Agreement for the project; credit to be provided in accordance with the provisions of Section 221 of the Flood Control Act of 1970. Section 221, as modified by Section 2003 of WRDA 2007, requires that the local work be performed after project authorization and after an In-Kind Memorandum Of Understanding is executed.

Under Section 408 (33 USC 408), temporary or permanent alteration, occupation, or use of any public works, including levees, for any purpose is allowable only with the permission of the Secretary of the Army. Under the terms of 33 USC 408, any proposed levee modification requires a determination by the Secretary that the proposed alteration, permanent occupation, or use of a Federal project will not be injurious to the public interest and will not impair the usefulness of the levee. The authority to make this determination and approve modifications to Federal works under 33 USC 408 has been delegated to the Chief of Engineers, USACE.

1.5.1.1 Feather River West Levee Project

SBFCA is proposing a levee improvement project along the Feather River west levee under the California Department of Water Resources (DWR) Early Implementation Program (EIP). EIPs are for flood control construction projects that rehabilitate, reconstruct, replace, improve, or add to the facilities of the State Plan of Flood Control. DWR provides bond funds to cost share for early implementation of state-federal flood control system modifications This two phase project proposes to construct levee improvements between the Thermalito Afterbay and the Feather River/Sutter Bypass confluence. Primary deficiencies of the levee include through-seepage, underseepage, and embankment instability. A Phase I Pre-Design Formulation Report was completed in August of 2011 and the 60% design was completed by March 2012. An EIS/EIR is being prepared for the project as part of a Section 408 application to obtain permission from USACE to alter project levees. The Draft EIS/EIR was released to the public in Spring 2012. This local project will be evaluated as one of the alternatives in the Pilot Study, and could potentially be considered for Section 221 crediting.

1.5.1.2 Star Bend Setback Levee Project

Construction of 3,400 feet of setback levee was recently completed within the study area under the DWR Early Implementation Program. The purpose of the setback levee was to address through-seepage, underseepage, and flow constriction issues. A request for approval under 33 USC Section 408 was granted and an application for consideration of Section 104 credit was

approved in 2009. This project and the request for Section 104 credit will be evaluated in the Pilot Study1.5.1.3 Lower Feather River Corridor Management Plan.

The purpose of the Lower Feather River Corridor Management Plan (CMP) by the Department of Water Resources is to develop a integrated strategy and long-term vision for managing the river corridor between the Yuba River and the Sutter Bypass in a way that facilitates and promotes economic sustainability and compatibility in future land uses, flood protection system management, maintenance of flood control facilities, and the restoration and enhancement of ecosystem functions and habitats.

1.5.1.4 Yuba River Basin, California, Marysville Ring Levee EngineeringDocumentation Report.

The Yuba River Basin Flood Risk Management Project, authorized by WRDA 99 Section 101(a) (10) and WRDA 07 Section 3041, is currently under reevaluation in the Yuba Basin General Reevaluation Report. During the project reevaluation it was determined that the Marysville Ring Levee was separable and common to all alternatives under consideration. The project team determined that the Marysville Ring Levee should proceed to implementation under the WRDA 99 authorization, as amended.

1.5.2 Systemwide Studies

1.5.2.1 Central Valley Flood Protection Plan

As required by State of California Senate Bill (SB) 5, the State has initiated the Central Valley Flood Protection Plan (CVFPP). The purpose of the CVFPP is to guide California's participation (and influence federal and local participation) in managing flood risk along the Sacramento and San Joaquin River systems. The CVFPP will require a 200-year level of flood risk management (1/200 annual exceedance probability) for urban and urbanizing areas by the year 2025, and no new development would be permitted if this target is not met. An urban area is defined as a developed area in which there are 10,000 residents or more. An urbanizing area is defined as a developed area or an area outside a developed area that is planned or anticipated to have 10,000 residents or more within the next 10 years.

The CVFPP proposes an initial systemwide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control (SPFC). This investment approach includes system and regional elements, some of which are located in the Sutter Pilot study area. These elements, including the Feather River West Levee Project, are being considered as part of the Pilot Study effort. The draft 2012 CVFPP was released for public review in January 2012 and must be adopted by the CVFPB by July 1, 2012. The CVFPP will be updated every five years.

1.5.2.2 Central Valley Integrated Flood Management Study

The Central Valley Integrated Flood Management Study (CVIFMS) is a continuation of the Sacramento and San Joaquin River Basins Comprehensive Study. The Comprehensive Study was initiated by USACE and The Reclamation Board of the State of California in 1998 and authorized in the 1998 Energy and Water Development Appropriations Act, Public Law 105-62. The U.S. House of Representatives Report 105-190, which accompanied the 1998 act, directed

USACE to conduct a comprehensive assessment of the flood management system for the Sacramento and San Joaquin River Basins. CVIFMS is the federal complement to the State CVFPP. Through CVIFMS, the State and USACE are pursuing a common and shared approach to flood risk management in the Central Valley. The Project Management Plan for CVIFMS was completed in 2011 and the study has received limited funding to date.

1.5.2.3 Sacramento Bank Protection Project

A USACE continuing construction project to address bank erosion and protection within the Sacramento River Flood Control Project.

1.5.2.4 Central Valley Hydrologic Study (CFHS)

The Department of Water Resources and the U.S. Army Corps of Engineers (USACE Sacramento District) have partnered in the development of the Central Valley Hydrology Study (CVHS). CVHS is a comprehensive assessment of stream flow frequencies and magnitudes in the Sacramento and San Joaquin river basins. The goal of the hydrologic analysis is to estimate peak flows and hydrographs for various annual exceedence probabilities to describe flood hazard throughout the basins.

1.5.2.5 Central Valley Floodplain Evaluation and Delineation Program (CVFED) DWR study of floodplains in the central valley.

1.5.2.5 Sacramento San Joaquin Comprehensive Study

"Sacramento River and San Joaquin River Basins Comprehensive Study, California. In response to the devastating floods of 1997, Congress directed the Corps of Engineers to conduct a comprehensive assessment of the entire flood control system within the existing study authorizations of the Sacramento River Watershed Management Plan (authorized by the Flood Control Act of 1962) and the San Joaquin River and Tributaries authority (authorized by 1964 Resolution of the House Committee on Public Works). The Comprehensive Study was initiated in 1998. The results were a post-flood assessment and system-wide hydrologic/hydraulic model that included extensive public involvement and planning for flood damage reduction and ecosystem restoration purposes.

1.6 PLANNING STRATEGY

1.6.1 Pilot Study Background

The Sutter Basin Feasibility Study was selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that have been outlined in the USACE *Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011), which was drafted by a workgroup of planning and policy experts from USACE and the Office of the Assistant Secretary of the Army for Civil Works referred to as the 17+1 Team.

This new process requires heavy involvement as well as input and decisions from the Vertical Team at multiple points throughout the study. The new process focuses on early decision

making and the reduction of unnecessary detail. Instead of following the traditional USACE planning milestones, the pilot study is divided into four phases, each with a key decision point and associated In-Progress Reviews (IPRs). Table 1 summarizes the four pilot study phases and associated decision points.

Table 1. Pilot Study Phases and Associated Decision Points

Pilot Study Phase	Decision Point
Scoping Phase	Decision Point 1 – Federal Interest Determination
Analysis Phase	Decision Point 2 – Tentatively Selected Plan and Draft Report
Review Phase	Decision Point 3 – Civil Works Review Board
Confirmation Phase	Decision Point 4 – Chief's Report

Based on the pilot program principles, the Sutter Basin Feasibility Pilot Study strategy focuses on utilizing an appropriate level of detail based on the decisions being made at each stage of the study. This strategy includes qualitative analysis that will be increasingly detailed at each Decision Point or IPR and early elimination of alternatives with little probability of implementation.

Decision Point 1 for the Sutter Basin Pilot Study was held in August 2011. The Decision Point 1 panel members reached consensus that there was a Federal Interest in continuing the study toward Decision Point 2, which will focus on Vertical Team agreement on the Tentatively Selected Plan. This document summarizes the increasingly detailed analysis that has been completed to date and concludes with the array of alternatives that will be evaluated in further detail as the team progresses toward selection of the Tentatively Selected Plan to be confirmed by the Vertical Team at Decision Point 2. Since the information presented in this document will be incorporated into the draft Feasibility Study/EIS/EIR, the format and content is designed to comply with the target length of 100 pages or less specified in the memorandum from MG Walsh issued on 8 Feb 2012.

1.6.2 Level of Detail

The Pilot Study utilizes five classes to describe the analysis level of detail and potential uncertainty. Results presented in this memorandum are based on a class 4 level of detail. The five classes are described in Table 1 of EM 1110-2-1302 Civil Works Cost Engineering. The table is based on ASTM E 2516-06, Standard Classification for Cost Estimate Classification System. The purpose of the classification system is to improve communication among all the stakeholders involved with preparing, evaluating, and using cost estimates (ASTM, 2011). Class definitions, as they relate to the Pilot Study, are described below.

Class 5 is least accurate and is the minimum required for assessing rough order of magnitude. The level of project definition is 0% to 2% of a complete definition. The expected cost accuracy (+/-) is 4 to 20 times the accuracy of the best (Class 1) estimate.

Class 4 is minimum required for Reconnaissance/905b Reports and alternative analysis in feasibility studies. The level of project definition is 1% to 15% of a complete definition. The expected cost accuracy (+/-) is 3 to 12 times the accuracy of the best (Class 1) estimate.

Class 3 is the minimum required for the feasibility NED Plan and Feasibility Sponsor Preferred Plan. The level of project definition is 10% to 40% of a complete definition. The expected cost accuracy (+/-) is 2 to 6 times the accuracy of the best (Class 1) estimate.

Class 2 is minimum required for Planning, Engineering, and Design up to 90% Plans and Specifications. The level of project definition is 30% to 70% of a complete definition. The expected cost accuracy (+/-) is 1 to 3 times the accuracy of the best (Class 1) estimate.

Class 1 is minimum required for Planning, Engineering, and Design 100 % Plans and Specifications and the Independent Government Estimate. The level of project definition is 50% to 100% of a complete definition. This is considered the most accurate estimate. It does not imply that all unknowns and risk are eliminated.

2.0 PROBLEM IDENTIFICATION

2.1 NATIONAL OBJECTIVE

The National or Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation. The National objective is not specific enough for the development of a water resource project. The formulation of alternative plans requires the identification of study specific planning objectives.

Benefits from plans for reducing flood risk accrue primarily through the reduction in actual or potential damages to affected land uses. There are three primary benefit categories, reflecting three different responses to a flood risk reduction plan. Inundation reduction benefits are the increases in net income generated by the affected land uses when the same land use pattern and intensity of use is assumed for with- and without-project conditions. Intensification benefits are increases in net income generated by intensified floodplain activities when the floodplain use is the same with and without the project but an activity (or activities) is more intense with the project. The third category of benefits is location benefits. If an activity is added to the floodplain because of a plan, the location benefit is the difference between aggregate net incomes (including economic rent) in the economically affected area with and without the project.

2.2 PUBLIC INVOLVEMENT

Public input has been received through coordination with the sponsors, coordination with other agencies, and through public workshops. As part of the NEPA and CEQA process, USACE, the CVFPB, and SBFCA have reached out to government agencies and the public to solicit input on the study. A Notice of Intent and a Notice of Preparation for the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) were published on May 20, 2011. Public scoping meetings were held in Yuba City and Gridley on June 27 and June 28, 2011. The

meetings provided the public and agencies an opportunity to learn about the study and provide input as to what components of the project are important to them, as well as what environmental resources should considered in formulation of plans and in impact analyses. A public scoping meeting summary is included in Appendix A.

The list below summarizes the views expressed in oral and written comments received during the four scoping meetings and in response to the Notice of Intent and Notice of Preparation. These represent the areas of interest or concern to the public and stakeholders in the study area:

Keep landowners apprised of associated activities occurring on their lands.

Keep the feasibility study on schedule so the State will be able to release early implementation program funding for the Feather River West Levee Project.

Coordinate with the State Department of Water Resources' Lower Feather River Corridor Management Project so that duplicative efforts pertaining to environmental studies are avoided.

Consider levee setbacks in the study area.

Consider a perimeter levee around Yuba City or a "J" levee on the south and west sides.

Project lead agencies must obtain appropriate water quality/discharge permits including those related to dewatering, discharge, sewer, and construction and land disturbance.

The area being studied is located in the planning area of the Yuba/Sutter Habitat Conservation Plan/Natural Community Conservation Plan (HCP/HCCP); therefore please provide the Sutter County Community Services Director's office with all future notices regarding this project.

Project teams need to review the current effective Flood Insurance Rate Maps for all counties and cities in the study area. Please note that these cities and counties are participants in the National Flood Insurance Program and the minimum, basic NFIP floodplain management building requirements are described in 44 Code of Federal Regulations (CFR) §§59–65.

General requests for more detailed information about the boundaries of each project and the relationship between the two projects.

A request to memorialize, in some way, the unreported deaths in 1955 caused by a levee break at Shanghai Bend.

The California State Lands Commission (CSLC) requests that as the Project proceeds, SBFCA submits additional information (e.g., detailed maps) to enable CSLC staff to determine if any components of the Project will require a lease or permit. CLSC additionally requests to be placed on any future distribution mailing list for the Project. A thorough project description should be included in the EIS/EIR in order to facilitate meaningful environmental review of potential impacts, mitigation measures, and alternatives.

The project's EIS/EIR should carefully consider issues and mitigation alternatives in order to formulate a more comprehensive and sustainable approach to flood management in the Sutter/Butte region. These include growth inducing impacts, downstream flood impacts, impacts under climate change, and evaluation of a broad range of alternatives.

Feather River Air Quality Management District (AQMD): Recommends discussing potential air quality and climate change impacts for both projects. The EIS/EIR should include a discussion of greenhouse gas emissions and climate change impacts. The project should submit a Fugitive Dust Control Plan to the Feather River AQMD prior to beginning work.

The California Department of Fish and Game (CDFG) would like to emphasize the critical importance of coordination with CDFG during the California Environmental Quality Act (CEQA) and regulatory processes.

- The Native American Heritage Commission (NAHC) recommends adequately assessing and mitigating project impacts related impacts to cultural resources.

2.3 PROBLEMS, OPPORTUNTIES, OBJECTIVES, AND CONSTRAINTS

Following inclusion of the Sutter Basin Feasibility Study in the National Pilot Program, the PDT and non-Federal sponsors participated in a study risk workshop with several members of the Vertical Team during which the following problem, opportunity, objective, and constraint statements were developed and refined.

2.3.1 Problems

A high risk of flooding from levee failure threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the study area.
Flooding has caused loss of life and extensive economic damages. A levee failure in 1955 resulted in unexpected rapid flooding of Yuba City and caused $327 million in damages (2011 dollars) and 37 recorded fatalities. Additionally, there have been three levee breaches adjacent to the study area since 1986. The adjacent levees are of similar design and age as those within the Sutter Basin Feasibility study area and the failures occurred prior to overtopping. . Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees do not meet USACE levee design standards and are at risk of breach failure at stages less than overtopping. This is evidenced by historical boils and heavy seepage at stages less than authorized design flows. Almost every location within the study area is afforded some flood risk reduction by these levees. . The risk of unexpected levee failure coupled with the consequence of deep flooding presents a continued threat to public safety, property, and critical infrastructure.

Existing levees have isolated the floodplains from waterways, which has eliminated channel capacity and significant floodplain habitats for native species, including federally listed species and other special status species. Conversion of high value habitats to other land uses has reduced the abundance, distribution and diversity of native species. Historically, lands subject to regular flooding or occasional overflow covered about one-third of the Sacramento Valley in 1880, or about 1 million acres. Within the study area, as throughout the Sacramento Valley, floodplain and native habitats have been lost or degraded. Federally listed species and other special status species that are dependent on floodplain habitats have declined.

2.3.2 Opportunities

There are FRM structural and non-structural opportunities to decrease known flood risks within the study area.

Direct and indirect conversion of land and water resources due to mining and agriculture has degraded ecosystems, reducing the quantity and quality of high value habitat. These factors

contributed to a number of species being listed as threatened, endangered or extirpated. Land formerly converted by mining or agriculture can be restored to more natural habitats in conjunction with FRM.

There is an opportunity to provide outdoor recreational features on FRM and ER project lands. The levees within the study area effectively cut off public access to waterways and associated recreation amenities. Facilities can be included at recommended flood risk management and ecosystem restoration features to provide public access and use and improved outdoor recreation experiences.

2.3.3 Objectives

The problems and opportunities identified for this study are refined and stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the without project conditions. The planning objectives include the following:

- Reduce the risk to life, health, and public safety due to flooding.
- Reduce the risk of property damage due to flooding.
- Reduce the risk of damage to critical infrastructure due to flooding.
- Encourage wise use of the floodplain.
- In conjunction with FRM, restore floodplain connectivity and associated dynamic riverine processes.
- In conjunction with FRM, restore aquatic, wetland, riparian, and terrestrial habitats for special status and other native species.
- In conjunction with FRM and ER, improve the public's access to and use of outdoor recreational opportunities in the study area.

2.3.4 Additional Non-Federal Sponsor Objective

The CVFPP will require a 200-year level of flood risk management (1/200 annual exceedance probability) for urban and urbanizing areas by the year 2025, and no new development would be permitted if this target is not met. Based on this requirement, the following non-Federal sponsor objective has been included:

- Reduce the probability of flooding to urban and urbanizing areas to less than 1/200 annual exceedance probability.

2.3. 5 Constraints

A constraint is a restriction that limits the extent of the planning process. It is a statement of things the alternative plans should avoid. Constraints are designed to avoid undesirable changes between future with and without-project conditions. The planning constraints include:

- Minimize significant adverse impacts to the human environment.

- Comply with applicable Federal laws, regulations, and policies such as the National Environmental Policy Act, Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act, Clean Air Act, and the National Historic Preservation Act.

2.4 EXISTING CONDITIONS

Existing conditions are those at the time the study is conducted and form the basis for extrapolation to other conditions. Existing conditions within the study area are discussed below.

2.4.1 Flow Frequency Estimates

A tabulation of the regulated peak flows at select locations and reaches within the study area is shown in Table 2. These estimates are based on unsteady hydraulic model output and may be revised at the TSP selection phase.

Table 2. Design Flows and Regulated Flows

Stream and Reach	Design Flow (cfs)	Regulated Peak Flows (cfs)						
		50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Sacramento River								
Colusa to Tisdale Weir	66000	44,000	48,000	50,000	53,000	55,000	59,000	68,000
Tisdale Weir to Sutter Bypass	30000	28,000	30,000	31,000	32,000	34,000	36,000	41,000
Feather River								
Oroville to Honcut Creek	210,000	60,000	100,000	150,000	150,000	150,000	174,000	327,000
Honcut Creek to Yuba River	210,000	49,000	106,000	156,000	146,000	151,000	195,000	311,000
Yuba River to Bear River	300,000	71,000	192,000	253,000	279,000	287,000	356,000	501,000
Bear River to Sutter Bypass	320,000	81,000	207,000	276,000	302,000	314,000	380,000	500,000
Sutter Bypass								
Meridian to Wadsworth Canal	150,000	57,000	102,000	126,000	155,000	184,000	228,000	327,000
Wadsworth Canal to Tisdale Weir	155,000	59,000	103,000	127,000	156,000	185,000	229,000	250,000
Tisdale Weir to Feather River	180,000	70,000	114,000	139,000	161,000	194,000	231,000	258,000
Feather River to Sacramento River	380,000	145,000	276,000	392,000	435,000	493,000	585,000	726,000
Wadsworth Canal								
East - West Interceptor to Sutter Bypass	1,500	750	1,900	2,550	3,050	3,550	4,050	4,720
Cherokee Canal								
Nelson Shipee Road to Western Canal	8,500							
Western Canal to Afton Road	11,500	6,000	10,300	12,100	13,200	14,300	15,200	16,300
Afton Road to Gridley-Colusa Road	12,500							

Peak Regulated flows obtained from HEC-RAS Model for the Sutter Basin Feasibility Study (August 2011 version).
Design Flows obtained from USACE file drawing 50-10-3334, Levee Channel Profiles, 15 March 1957
Note: Peak flow is the highest of the Sacramento or Shanghai Bend storm centering peak flows
Note: Wadsworth and Cherokee Canal are unregulated streams
Note: Peak flows for 0.5% and 0.2% ACE include effects from levee overtopping and may be reduced from their possible maximums.

Table 2 is subject to update by Peterson-Brustad Inc after new flood routings are complete. Flow frequency estimates for the Feather River and Sutter Bypass are based on analysis described in the Sacramento and San Joaquin River Basins Comprehensive Study and Yuba River Basin Feasibility Study documentation. Flow Frequency curves and hydrographs of unregulated flow were developed for the 50% (1/2) to 0.2% (1/500) annual chance Exceedance probability (ACE) frequencies. Regional synthetic hydrology presented in these studies represents the best available data for the large flood sources (Sutter Bypass and Feather River) of

the Sutter Basin Feasibility Study. These hydrologic analyses have also been used as the foundation for several other feasibility studies in the region, such as the American River Common Features and Yuba River Basin studies. DWR and USACE are in the process of developing new hydrologic frequency estimates. However, the results will not be available until late 2012. Therefore, this study utilizes the results from the San Joaquin River Basins Comprehensive Study hydrologic analysis.

Synthetic hydrology of the Sacramento and San Joaquin River Basins Comprehensive Study was based on transformation of unregulated hydrologic conditions to regulated conditions. This was accomplished by developing balanced unregulated hydrographs based upon historically patterned storm events. Balanced hydrographs have the same annual exceedance frequency for all flood durations. For example a 10% (1/10) ACE hydrograph contains the 10% (1/10) ACE 1-day flow, 10% (1/10) ACE 3-day average flow, 10% (1/10) ACE 5-day average flow etc. These balanced hydrographs were then transformed to regulated hydrographs using an HEC-5 reservoir operations model of the system. The HEC-5 model, also developed and calibrated for the Sacramento and San Joaquin River Basins Comprehensive Study, simulates reservoir operations and produces regulated hydrographs. The comprehensive study transferred the hydrographs from the HEC-5 model at 'handoff' points and modeled in more hydraulic detail using UNET. The portion of the UNET model downstream of Sacramento River at Colusa and Butte Slough near Meridian was replaced by an HEC-RAS unsteady model developed for this study (see hydraulics section). Hydrographs at Sacramento River at Colusa and Butte Slough near Meridian were obtained from the UNET model. All other hydrograph boundary conditions were obtained from the HEC-5 model.

The Sacramento and San Joaquin River Basins Comprehensive Study hydrology utilized a storm centering approach to evaluate possible hydrologic scenarios. A storm centering is a storm positioned (centered) over a watershed to produce flow rates or stages of specific frequencies at the specified runoff location or gage. Multiple storm centering scenarios are possible due to the diverse spectrum of floods that can occur from different combinations of concurrent storms on tributaries, orographic influences, and other factors that influence regional rainfall runoff events. The Sacramento and San Joaquin River Basins Comprehensive Study evaluated a suite of storm centerings and selected the centering that produced the largest stage or flow rate at a given location. For the smaller geographic area of the Sutter Basin Feasibility study area, the Sacramento and San Joaquin River Basins Comprehensive Study results were reviewed and narrowed to two possible centerings. The Sacramento storm centering predominantly applies to the Sacramento River and the Sutter Bypass, while the Shanghai Bend storm centering predominantly applies to the Feather and Yuba Rivers.

Flow frequency of the Cherokee Canal was estimated by detailed methods using gage records on the Cherokee Canal and contributing streams. Frequency curves and hydrographs of unregulated flow were developed for the 50% (1/2) ACE to 0.5% (1/200) ACE events.

Flow frequency of Wadsworth Canal was estimated by detailed methods using gage records. Frequency curves and hydrographs of unregulated flow were developed for the 50% (1/2) ACE to 0.5% (1/200) ACE events.

Hydrologic analysis of the Sutter Basin interior area was done by approximate methods using a conceptual level HEC-HMS model. Approximate methods were deemed suitable because the feasibility study is not evaluating FRM projects to address flooding at the existing interior drainage pump locations. Model parameters were based on comparison to measured runoff volumes at the three DWR pumping plants during the February 1983 and March 1986 storm events. It was determined that approximately 24 days are required to pump the volume of a significant flood out of the basin, therefore a 30-day storm duration has been used to produce runoff estimates..

2.4.2 Hydraulics

Hydraulic analyses were performed using one-dimensional and two-dimensional models.. Channel stages were estimated using a system wide HEC-RAS one-dimensional unsteady flow model. Floodplain stages were estimated using a FLO-2D two-dimensional floodplain model of the study area. HEC-RAS models were developed for two levee overtopping scenarios: Scenario A – infinitely tall levee with no breach and Scenario B – existing levee heights with simulated levee breach. FLO-2D was used to model overland flow from each simulated levee breach in Scenario B. Water surface profiles and levee breach inundation maps were developed for hydrologic events ranging from 50% (1/2) to 0.2% (1/500) ACE median hydrologic events. All models and stage data are relative to the NAVD88 vertical datum.

Water surface profiles for Sutter Bypass, Feather River, and Wadsworth Canal were estimated using a system wide HEC-RAS model. Profiles were computed for two hydrologic storm centerings (see hydrology section for description of storm centering). The final profile is the higher of the two possible storm centering profiles. Model geometry was based on topographic and bathymetric mapping collected for the Sacramento and San Joaquin River Basins Comprehensive Study (1997-1999). Manning's roughness values were based on unsteady model calibration and verification of the 1997 and 2006 flood events.

Water surface profiles of Cherokee Canal were estimated using a HEC-RAS model. Water surface profiles were computed for a single storm centered above Highway 162. Model geometry was based on topographic and bathymetric mapping provided by DWR.

Levee breach simulations were independently performed for thirteen spatially distributed levee breaches throughout the study area. Breach locations were placed at representative locations based on levee geotechnical characteristics and floodplain inundation characteristics. Eight breaches were simulated on the Feather River from Thermalito to Sutter Bypass. Two breaches were simulated on the Sutter Bypass between Wadsworth Canal and Feather River. Two breaches were simulated on Cherokee Canal with one upstream and one downstream of the Union Pacific Railroad. A single breach was simulated on Wadsworth Canal. All breach simulations assume remaining levee reaches would be overtopped without failure.

For each hydrologic frequency event, floodplain inundation maps were developed for the thirteen spatially distributed levee breaches throughout the study area. The inundation maps were conditional (assumed a levee breach). The hydrologic frequency of the inundation map is not the frequency of inundation. Inundation frequency estimates have to account for performance of the levee (probability of the breach). The inundation frequency is computed in the economic flood damage analysis using the geotechnical performance curves.

Floodplains for existing conditions were estimated by including areas impacted by a breach of any levee that had less than 90% reliability for the given flood. Floodplain depth maps that combine the probability of the conditional floodplain inundation into a single ACE event were not developed. The probability of flooding from each source is based on the hydrologic frequency, stage-discharge relationship and the geotechnical performance. The combination of these parameters is done in the FDA economic model. The FDA economic model does not have the capability to display the geographic variability of flood risk on a map because it aggregates the results at index locations.

2.4.3 Geotechnical Levee Performance

Geotechnical conditions of the existing levees within the study area were evaluated to assess the probability of unsatisfactory performance/reliability (levee fragility curve) over a range of flood events. Risk and uncertainty based methods were utilized in accordance with ETL 1110-2-556, ETL 1110-2-561, and accepted guidance for planning studies.

Data gathered by USACE and the State of California's Urban Levee Evaluations (ULE) Program were utilized. The State's ULE Program performed a comprehensive geotechnical investigation suitable for feasibility studies between 2007 and 2012. ULE subsurface explorations have been conducted at approximately 1,000 foot intervals throughout the entire study area excluding Cherokee Canal. The inventory was augmented with nine additional explorations conducted for this study along the east levee of Cherokee Canal performed by the Corps. The explorations include Cone Penetration Tests (CPT), auger borings with standard penetrations tests, and sonic borings. Geophysical data including helicopter electromagnetic surveys (HEM) were performed as well as data gathering on past performance and as-built conditions.

The ULE evaluation subdivided the levee segments within the study area into 50 reaches, based on expected geotechnical performance. For the Pilot Study, the ULE reaches were adopted as subreaches and grouped into 12 larger reaches with similar characteristics for the economic analysis. An additional reach for Cherokee Canal was also evaluated, resulting in a total of 13 reaches.

An evaluation was performed for each reach using methods described in ETL 1110-2-556 (Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies) and consistent with applicable guidance on underseepage described in ETL 1110-2-569 (Design Guidance for Underseepage).

For each of the 12 reaches, a levee fragility curve was prepared for the existing levee conditions. These curves included probability of failure for the following modes:

- Underseepage
- Landside Slope Stability
- Judgment (Erosion, Animal Burrow, Penetrations)

An evaluation of through-seepage was not conducted at this time. Through-seepage is estimated to be a minor factor and will be included during evaluation of the selected alternative. The

probability of geotechnical levee failure for each location is provided in Table 3. The table is based on the stage estimates for a median hydrologic event.

Table 3. Probability of Geotechnical Failure by Median Hydrologic Annual Chance Exceedance (ACE)

	Probability of Geotechnical Failure by Median Hydrologic ACE						
	50% (1/2)	10% (1/10)	4% (1/25)	50% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Feather River							
Hamilton Bend LM0.51	0.00-0.00	0.05-0.11	0.22-0.45	0.22-0.45	0.22-0.45	0.40-0.63	0.89-1.00
MA 16-LM0.90	0.00 -0.00	0.00-0.03	0.05-0.32	0.14-0.42	0.13-0.41	0.35-0.61	0.94-1.00
LD9-LM0.52	0.00-0.00	0.09-0.19	0.26-0.35	0.30-0.41	0.31-0.42	0.49-0.63	0.88-1.00
LD1-LM9.31	0.01-0.02	0.02-0.02	0.06-0.11	0.09-0.15	0.11-0.16	0.19-0.25	0.39-1.00
LD1-LM3.99	0.00-0.00	0.12-0.17	0.21-0.27	0.25-0.30	0.26-0.32	0.35-0.40	0.46-1.00
MA3-LM4.92	0.00-0.00	0.29-0.35	0.38-0.44	0.41-0.46	0.44-0.49	0.49-0.54	0.57-0.60
Sutter Bypass							
SBE-LM6.2	0.19-0.24	0.31-0.39	0.40-0.47	0.46-0.53	0.52-0.59	0.60-0.65	0.65-1.00
SBE-LM11.9	0.19-0.24	0.31-0.39	0.41-0.49	0.46-0.53	0.51-0.58	0.58-0.64	0.64-1.00
Wadsworth Canal							
WCE-LM0.84	0.02-0.05	0.08-0.14	0.14-0.39	0.35-0.60	0.56-0.76	0.78-1.00	0.89-1.00
Cherokee Canal							
CCE-LM9.5	0.08-0.19	0.22-0.32	0.27-1.00	0.30-1.00	0.33-1.00	1.00-1.00	1.00-1.00

2.4.4 Flood Damages

Existing condition damages were estimated using results from the hydrologic, hydraulic, and geotechnical analysis described above. For this preliminary screening phase, Expected Annual Damages (EAD) were estimated for Yuba City using the HEC-FDA software program and graphical probability-stage curves. Total damages for the remaining study area were estimated based on the ratio of total damageable property between the unknown area and the Yuba City area. Yuba City contains approximately 70% of the total damageable property within the study area.

An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte counties. Building attribute data were used to determine land use and valuation of structures and contents. Detailed GIS data were unavailable for all multifamily and commercial properties. These data were estimated using available digitized footprints and aerial imagery. Field visits were conducted to collect and validate the base inventory data.

Parcels with structures were categorized by land use and grouped into the following categories:

Residential – Includes all parcels represented by a single unit such as detached single-family homes and parcels with more than one unit such as apartment complexes, condominiums, and multiplex units. Each parcel may have multiple structures.

- *Commercial* – Includes retail, service stations, office buildings, restaurants, and shopping centers.

- *Industrial* – Includes warehouses, light and heavy manufacturing facilities, and food and agricultural processing facilities.

- *Public* – Includes both public and semi-public uses such as post office, fire dept, hospitals, government buildings, schools, and churches.

The value of damageable structures was estimated based on depreciated replacement values. The depreciated replacement value of a structure was determined by multiplying the structures square footage by the cost per square foot and a remaining-value ratio. Values for cost per square foot were obtained from the Marshall and Swift Valuation Service based on land use, building type, construction class, and quality. The remaining-value ratio was based on the factors such as condition of the structure and the year the structure was built.

The value of damageable building contents was estimated as a percentage of depreciated structure value based on associated land use. Content percentages were based on the expert elicitation findings used in the *American River Watershed Common Features Natomas Basin Post-Authorization Change Report and Interim General Reevaluation Report* (USACE, 2010).

The total value of damageable property (structures and contents) within the Sutter Basin study area is estimated at $7.1billion. Table 4 displays the total value of damageable property by category.

Table 4. Damageable Property ($1,000's)

Stutter Basin Feasibility Study Area EIA	Structure Value ($1,000's)	Content Value ($1,000's)	Total Value ($1,000's)	Percent of Total
Biggs	54,757	23,560	78,318	1%
Gridley	278,501	133,560	412,061	6%
Live Oak	250,603	105,118	355,721	5%
Yuba City	3,327,010	1,636,411	4,963,421	77%
Rural-Butte	160,829	66,573	227,401	4%
Rural-Sutter	302,114	132,396	434,510	7%
TOTAL	$4,373,815	$2,097,617	$7,118,575	100%

Agricultural damage analysis is currently being completed. Agricultural crop and equipment values are estimated to be approximately 10% of the value of the total urban damageable property ($647 million). Future analysis will include an assessment of production costs of crops grown within the project area and the inventory of crops expected to be flooded.

2.4.5 Environmental

Existing and future without-project conditions have been developed for the study area and are described in the draft *Sutter Basin Feasibility Study Environmental Without-Project Conditions Report* (ICF International, 2011). This report will be the basis for the "Affected Environment" and "No Action Alternative" sections of the Sutter Pilot Feasibility Study/EIS/EIR. Following is a brief summary of existing environmental conditions based on the report.

The study area is located within the northern portion of California's Central Valley. The Sacramento Valley is a semi-arid region with an annual rainfall of approximately eighteen inches. There are two distinct annual seasons, a hot dry summer and a cool wet winter. Approximately eighty percent of the annual rainfall occurs in between October to March.

Sutter County is primarily rural, with extensive agricultural areas and a low population density. The county is one of California's major agricultural counties and its traditional job base is agriculture. Eighty-six percent of Sutter County's lands are dedicated to agriculture; uses include field and row crops, orchards, rice, livestock grazing, dry farming, and timber according to the Sutter County General Plan, dated 2010. Nearly two thirds of the county's residents live in the incorporated cities of Live Oak and Yuba City. The California Department of Finance provides population data estimates and projections for cities and counties throughout California. Based on these estimates, the population of Sutter County increased from 78,930 to 99,154 between April 2000 and January 2010. For that same timeframe, the population within the incorporated cities of Live Oak and Yuba City grew from 6,229 to 8,791 and 36,758 to 65,372, respectively.

Butte County occupies the northern portion of the study area and includes the small communities of Gridley and Biggs. Agricultural lands dominate the landscape of the county. Agriculture is a major employment sector in Butte County. According to the California Department of Finance, between April 2000 and January 2010, the population of Butte County increased from 203,171 to 221,768. For that same timeframe, the population of the incorporated City of Gridley rose from 5,408 to 6,454. The population within the City of Biggs declined from 1,793 to 1,787.

Due to agricultural development and urbanization little historic native habitat remains within the Basin. According to some estimates, riparian forests in the Central Valley have declined by as much as 89 percent from the time of the Gold Rush. The study area is largely agricultural with about 80 percent of the area in farmland (orchards and rice fields), 10 percent in urban and developed lands, and about 10 percent in natural areas. Most remaining natural wetland areas that do exist are protected and are in State (Department of Fish and Game (CDFG)) or Federal (United States Fish and Wildlife Service (USFWS)) ownership. Most of the remaining land is used for agriculture and does not contain native vegetation. Existing rice fields however do provide valuable waterfowl habitat and habitat for the federally-listed threatened giant garter snake (GGS).

The project levees are covered primarily with grasses and forbs with widely scattered trees. While the levees are relatively free of woody vegetation compared to other levees within the

Sacramento region, the levees have been determined based on a periodic inspection in 2010 to be in noncompliance with ETL-1110-2-571, *Engineering and Design: Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (USACE, 2009). Efforts are underway to determine how to bring the levees into compliance while preserving where feasible vegetation. Obtaining a variance and/or incorporating design measures to retain vegetation are strategies being considered.

Along the Feather River within the designated floodway, significant habitats of riparian woodlands and grasslands occur. A wide band of riparian vegetation up to a mile in width extends from the river to the project levees. Most reaches of levees on the Feather River are set back some distance from the river channel allowing for a significant riparian corridor. This is unlike the Sacramento River where below Colusa the levees tightly constrain the river. Riparian habitat types include willow riparian, cottonwood riparian, and Great Valley mixed riparian.. Riparian habitats in general provide shelter, nesting, and foraging habitat for countless wildlife species in the Central Valley including numerous species of migratory birds protected via the federal Migratory Bird Treaty Act 1973.

Significant areas of native riparian vegetation along the Feather River are within the California Department of Fish and Game Feather River Wildlife Management Area and the Audubon Society's Bobelaine Sanctuary. Both areas include typical valley riparian species interspersed with freshwater marshes. The riparian tree species include large Fremont cottonwood trees along with sycamore, black walnut, Oregon ash, and valley oak. The understory vegetation consists of box elder, willow, wild rose, blackberry, wild grape, and poison oak.

A number of Federal and State listed species are known to occur or potentially occur in the study area. Many of these species are located within the riparian areas along the Feather River. Federally listed species identified by the USFWS as potentially occurring in the study area include the valley elderberry longhorn beetle, giant garter snake, vernal pool fairy shrimp, California tiger salamander, Central Valley steelhead, Central Valley spring-run Chinook salmon, and the green sturgeon. State listed species include the bank swallow, Swanson's hawk, western yellow-billed cuckoo, greater sandhill crane, and giant garter snake.

The Feather River and other rivers in the general area provide spawning, rearing, and migratory habitat for a diverse assemblage of native and nonnative fish species. Native species present in these streams can be separated into anadromous (species that spawn in fresh water after migrating as adults from marine habitat) and resident species. Native anadromous species include two runs of Chinook salmon, steelhead, green and white sturgeon, Pacific lamprey, and river lamprey. Native resident species include Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, hardhead, California roach, and rainbow trout. Nonnative anadromous and resident species are also present. Chinook salmon, steelhead, green sturgeon, Pacific lamprey, and Sacramento splittail have experienced declines in abundance as a result of natural and human-related factors.

The elderberry shrub, present within the riparian zone and near project levees, is the sole host plant to the federally-listed threatened valley elderberry longhorn beetle. Elderberry shrubs are a common component of riparian forests and adjacent uplands throughout California's Central Valley. The GGS, a state and federally threatened species, also has potential habitat along the

existing levees. Typically inhabiting marshes, sloughs, ponds, small lakes, and low gradient streams, GGS also heavily utilize agricultural wetlands such as irrigation and drainage canals, rice fields, and the adjacent uplands. These two listed species and the Swanson's hawk are considered the most likely species to be potentially adversely affected by levee construction activities. In some locations, elderberry shrubs and Swanson hawks can occur in the riparian habitat in close proximity to the levees and GGS aquatic habitat occurs in canals and ditches located near the toe of levees. Additional information regarding habitat conditions is included in the *Environmental Constraints Analysis for the Feather River West Levee Project* (ICF International, 2011), which was prepared to identify sensitive habitat areas along the west levee of the Feather River.

The Sutter National Wildlife Refuge operated by the USFWS is located within and along the Sutter Bypass consists of about 3,000 acres along about 20 miles of riparian channels on both sides of the interior of the bypass. Within the Sutter Bypass, riparian and emergent marsh vegetation is limited to narrow bands of woody vegetation near the low flow streams waterward of the project levees. Cottonwood and willow are the most common riparian tree species. During periods of high flow when the bypass is flooded, the bypass provides seasonal winter wetland habitat for migratory waterfowl. Segments of drainage ditches that are located landward of the Sutter Bypass and parallel the levee toe support areas of emergent marsh and the State and Federally-listed threatened GGS.

Various recreation activities are actively pursued along the banks of the Feather River. Fishing and boating are the major recreational activities. There are a number of County and city parks along the river. CDFG operates several areas within the Feather River Wildlife Area that are managed primarily for wildlife but offer recreation opportunities, including hunting, fishing, bird watching, and nature study. During the NEPA scoping period for the study, a concern was expressed regarding lack of river access for recreation. Use of levee top for hiking and biking is restricted because the public is not allowed to use most of the levee tops for recreation.

The study area is located in a federally designated nonattainment area for PM10 (particulate matter equal or less than 10 microns in diameter) under the Clean Air Act. Construction generated emissions of dust and diesel particulate matter is an air quality health concern.

2.5 FUTURE WITHOUT PROJECT CONDITION

The future without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project and constitutes the benchmark against which alternatives are evaluated. These forecasts of future conditions are from the base year (year when a project is expected to be operational) to the end of the period of analysis (50 years). Future without-project conditions for this study are projected assuming a base year of 2020 and a 50 year period of analysis out to year 2070. Current economics efforts do not include a future without project condition with future development estimates. It is scoped to do these calculations after the TSP selection as more detailed analysis is warranted. Some discussions on possible approaches follow.

Circumstances regarding flood risk may influence community development and population growth. One such circumstance is through imposition of development restrictions if target levels of flood protection are not in place. As stated in Section 1.5.2, the CVFPP will require a 200-year level of flood risk management (0.5% (1/200) ACE) for urban and urbanizing areas by the year 2025, and no new development would be permitted if this target is not met. As an interim measure under SB 5, no new development would be permitted if adequate progress is not being made toward this goal by 2015.

These measures apply to the study area and therefore may result in development restrictions if the required conditions are not met, which in turn may negatively influence community build-out as prescribed in the general plans, and similarly may negatively influence population growth projections. Therefore, two future growth scenarios have been described to bracket the potential circumstances of full growth and limited growth. Although these scenarios are highly speculative, the California Department of Finance assisted by providing unpublished data to support the potential population changes based on these scenarios. The scenarios are presented below.

2.5.1 Full-Growth Scenario

The following conditions apply to the full-growth scenario:

- The communities of Yuba City and Live Oak as well as surrounding areas within Sutter County are currently mapped by the Federal Emergency Management Agency (FEMA) as Zone X. It is anticipated that FEMA will issue updated floodplain maps for the portion of the study area within Sutter County by 2013. Updated FEMA Flood Insurance Rate Maps for the portion of the study area within Butte County became effective on January 6, 2011. The communities of Biggs and Gridley as well as surrounding areas within Butte County are mapped as FEMA Zone X. Under the full-growth scenario, current officially adopted FEMA maps would remain in place; no new FEMA restrictions.
- No SB 5 restrictions would be triggered; 200-year protection would be met via non-Federal actions area wide or over large planning areas.
- Current municipal general plans would be built out and continue beyond those plans to 2070; planned community development would continue as described in the general plans.
- Population growth would continue as described under current municipal general plans and would continue beyond those plans to 2070.

2.5.2 Limited-Growth Scenario

The following conditions apply to the limited-growth scenario:

- Current officially adopted FEMA maps would remain in place; no new FEMA restrictions.
- SB 5 restrictions would be triggered; 200-year protection would be met on a per parcel basis or over small, discrete planning areas.
- Current municipal general plans would not be built out beyond 2025; limited community development would continue but would be shifted from urbanized areas, under SB 5

restrictions, to non-urbanized areas.

- Population growth would continue but would be restricted according to community development.

2.5.3 Population

2.5.3.1 Full-Growth Scenario

According to California Department of Finance (2007c), "California's population is projected to reach almost 60 million people by 2050, adding over 25 million since the 2000 decennial census." In this time frame, Sutter County is expected to more than triple in size and experience the state's largest population increase (+255%). In 2050, the total population of Sutter County is expected to reach 282,894 (California Department of Finance 2007a), and the total population of Butte County is expected to reach 441,596 (California Department of Finance 2007b).

Specific population and other long-term projection data related to socioeconomics are not yet available for 2070; however, California Department of Finance prepared unofficial 2070 population estimates for Sutter and Butte Counties for this project. It is estimated that the population of Butte County will be 512,095 and the population of Sutter County will be 341,216. These projections are based on very preliminary analysis of migration and fertility trends, which will change. Also, it is important to note that 60-year projections are subject to an enormous amount of potential external changes that could render these values completely inaccurate (Schwarm pers. comm.). Based on these projections, the population in the study area would continue to increase, and it can be assumed that employment, income, and the demand for housing would also increase between 2011 and 2070.

2.5.3.1 Limited-Growth Scenario

The California Department of Finance prepared unofficial population estimates for Sutter and Butte Counties under the limited-growth scenario (Schwarm pers. comm.). It is estimated that the population of Butte County will be 438,676 and the population of Sutter County will be 301,516. As described above, these projections are based on very preliminary analysis of migration and fertility trends, which will change. Butte County is assumed to be slightly more affected by SB 5 and the provisions associated with it than Sutter County. Also, it is important to note that 60-year projections are subject to an enormous amount of potential external changes that could render these values completely inaccurate. However, under the limited-growth scenario, the population of both counties would be significantly less than it would be under the full-growth scenario.

2.5.4 Land Use

2.5.4.1 Full-Growth Scenario

It is anticipated that build out of Sutter County's General Plan will be achieved by the year 2070. Development rates in 2070 are expected to coincide with population growth over the next 60 years. The county's land use goals include maintaining adequate land use supply and preserving

agricultural heritage and natural resources. It is anticipated that in 2070 the primary land use will be agriculture in the unincorporated county. The main areas of growth will be in the Yuba City and Live Oak spheres of influence, rural planned communities, employment corridors, and industrial/commercial use. By 2070 the majority of the land use in unincorporated Butte County in the study area would remain in agriculture. It is likely that the 2030 build out numbers projected in the Butte County General Plan 2030 would be realized. While it could be assumed that the build out numbers for 2030 would be realized earlier, the county does not have a history of reaching planned build out numbers.

2.5.4.2 Limited-Growth Scenario

Under a limited-growth scenario in 2070, the estimated population of Sutter and Butte Counties will be approximately 13% smaller than the population numbers under a full-growth scenario. It is anticipated that there will be continued growth in cities and counties in the study area between 2025 (the year in which the CVFPP will require limitations on new development in urban and urbanizing areas) and 2070. Growth has been the trend within the study area and is anticipated, planned for, and encouraged in the municipal general plans. As this trend continues into the future, it will broaden the economic base. It is probable that because new development will be restricted in urbanized areas, existing smaller cities (such as Gridley, Biggs, and Live Oak) and unincorporated towns will grow and new communities will come into existence in areas with populations presently below 10,000. This will increase suburban growth, with the city spreading outward through low-density and auto-dependent development on rural and often unincorporated lands. As a result of new populations moving to currently undeveloped areas, there is the potential for cities and counties to change land use designations to accommodate the shift in population, despite the current emphasis on preserving agricultural lands for economic and recreational benefits.

The potential effects of the limited-growth scenario on land use in all jurisdictions in the study area could include conversion of important farmland to non-agricultural uses. Because housing in urban and urbanizing areas will be fully occupied and development limited after 2025, new housing will likely be driven to rural areas. This may ultimately require lands that are designated for agriculture, recreation, or open space to be converted to uses that support the development of housing. Land may also be converted to accommodate commercial districts that support the developing suburban communities. Furthermore, temporary zoning conflicts associated with suburban development are likely to occur.

In both Sutter and Butte Counties, it is likely that the dominant land use in 2070 under a limited-growth scenario will continue to be agriculture. This is because of the foreseeable demand for the area's agricultural commodities. Agriculture represents the economic base for both counties, and the preservation of open space and agricultural lands is highly regarded in the region.

2.5.5 Additional Assumptions

Additional assumptions regarding the future without-project condition are listed below:

- For purposes of evaluating the transfer of flood risk, the future without-project condition will assume the levees do not fail due to geotechnical conditions since their original design was not based on failure assumptions.

- Ongoing levee maintenance will result in no change to geotechnical conditions and levee performance curves.

- Oroville and New Bullards Bar reservoirs on the Feather and Yuba River Systems will continue to be operated using the existing rule curves.

- Vegetation and topographic conditions within the channel are expected to remain the same as existing conditions.

- Remaining natural areas are not expected to substantially decline in acreage and value over the period of analysis.

- Future urban development is expected to occur within agricultural lands rather than natural areas based on current adopted general plans.

- Since refinements, additions, and deletions of elements associated with the Systemwide Investment Approach presented in the 2012 CVFPP are anticipated, these elements will not be included in the future without-project condition.

- Quantitative estimates of flood damage related to climate change will not be made. However, a sensitivity analysis to changes in hydrologic frequency will be conducted. Evaluating the impact of climate change on local flood extremes would require lengthy and complex analysis. For example, evaluation of global climate models would be necessary to estimate changes in extreme rainfall amounts and temperature as well as seasonal changes to snowpack. Hydrologic modeling would be necessary to compute runoff from the basins hydrologic characteristics, precipitation amounts, precipitation temperature, and snowmelt excess. Reservoir modeling would be necessary to evaluate flood control operations based on downstream control points. DWR is developing a new methodology for estimating the impacts of climate change on flood hydrology (DWR, 2011). The study will evaluate climate change impacts on extreme events based on estimated changes to local extremes. The results of this complex analysis will not be available within the schedule of this study.

- Section 104 of WRDA 86 allows for the plan formulation analysis to exclude work conducted by the sponsor from the without project condition, thereby allowing the work to potentially be incorporated in to the recommended plan, if it is found to be in the Federal interest. Since the application for consideration of Section 104 credit for the completed Star Bend setback levee was approved in 2009, this project will not be considered part of the future without-project condition.

- Per direction from the Vertical Team at In-Progress Review #1, the Feather River West Levee Project <u>will not</u> be considered part of the future without-project condition (assumes no contract prior to the Chief's Report for the pilot study).

3.0 MEASURES AND CONCEPTUAL ALTERNATIVES

3.1 PLAN FORMULATION PROCESS

The plan formulation process develops and evaluates alternative plans to address the needs and desires of society as expressed in specific planning objectives. Accordingly, the TSP best satisfies the objectives as well as the Federal interest. Consistent with the Federal Water Resources Council's Principles and Guidelines (P&G) and the Planning Guidance Notebook (ER 1105-2-100), the procedure is broken down as follows:

- Establish specific planning objectives.
- Determine the nature and extent of issues to be addressed and identify the most important issues raised by the proposed action.
- Engage Federal and State resource agencies in the formulation process.
- Define constraints and criteria for formulating an implementable plan.
- Identify management measures to address the planning objectives. Retain those measures that are effective and produce NED benefits at less cost than other measures.
- Develop alternatives from the measures to meet or address the planning objectives and criteria.
- Compare alternatives in terms of economic cost and benefit, and identify the alternative that reasonabily maximizes net NED benefits if applicable.
- Identify the LPP.
- Reconcile differences between the NED plan and the LPP to develop a TSP that retains Federal interest. The overall TSP must continue to be economically feasible, and any deviation from the NED must be justified and must be approved by the ASA (CW). Any significant deviation from the NED may be a local sponsor responsibility and the local sponsor may be required to pay for entire project costs beyond what was identified in the NED Plan.

3.2 MANAGEMENT MEASURES

A broad array of management measures was developed based on information from existing reports and studies, as well as public input and professional judgment. The measures included the following categories: FRM structural, ER with FRM structural component, FRM non-structural, and recreational. These measures were presented at the Sutter Basin Pilot Study

Critical Thinking Charette held at the Sacramento District on July 18-19, 2011. The charette was attended by the PDT and non-Federal sponsors, along with several members of the Vertical Team and the National Pilot Program 17+1 Team. The measures were presented in an interactive format utilizing GIS and Google Earth. The team reviewed each measure, identified additional measures, and then evaluated the measures based on study objectives, study constraints, and Water Resources Council Principles and Guidelines (P&G) criteria. A group decision was made as to whether each measure should be retained or dropped from further consideration. Table 5 provides a description of the measures evaluated at the charette and indicates whether each one was retained or dropped and the reason(s) for dropping. Of the total 46 measures that were evaluated, 32 were retained.

Table 5. Summary of Measures Considered

ID	Measure	Measure Description	Retained	Dropped	Primary Reason(s) for Dropping Measure
S1	Biggs Ring Levee	Construct ring levee around highly developed area of Biggs.	X		
S2	Gridley Ring Levee	Construct ring levee around highly developed area of Gridley.	X		
S3	Live Oak Ring Levee	Construct ring levee around highly developed area of Live Oak.	X		
S4	Yuba City Ring Levee	Construct ring levee around highly developed area of Yuba City.	X		
S5	Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend	Fix in Place Feather River West Levee from Thermalito to Shanghai Bend.	X		
S6	Southern Portion of J-Levee	Construct Southern Portion of J-Levee. This measure would prevent potential levee failures on Sutter Bypass or Feather River downstream of Shanghai bend from backing up into Yuba City. However, if a failure occurred upstream of Shanghai, the measure would increase flood depths in Yuba City by ponding behind the J- levee.	X		
S7	Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee	Fix in Place existing Feather River west levee from Shanghai Bend to Sutter Bypass, Sutter Bypass East levee, and Wadsworth Canal Levee.	X		
S8	Butte Bypass	Construct a 1400 foot wide bypass from Feather River to Butte Basin.		X	This measure was dropped from further consideration because it would need to be combined with Sutter Bypass increase in capacity and additional easements. This measure would also require a fix-in-place levee. Additional engineering requirements along Feather River and Sutter Bypass and/or ring levee would be needed before this measure would be effective.

S9	Sutter Bypass Setback Levee	Construct a 500 foot setback levee along Sutter Bypass.	X		This measure would utilize the existing DWR pumping stations.
S10	Northern Feather River Setback Levee	Construct a 5.3 mile long setback levee.	X		
S11	Sutter Bypass and Feather River Confluence Setback Levee	Construct 2.1 mile long setback levee near Feather River and Sutter Bypass confluence.	X		
S12	Star Bend Setback Levee	Construct a 0.8 mile long setback levee at Star Bend.	X		
S13	Oroville DFG Wildlife Management Area – Degrade Land Surface and Restore Wetlands	Measure consists of degrading land surface and restoring wetlands. However, current ground surface is not hydraulically efficient and measure may only result in a small stage reduction.	X		
S14	Nelson Slough Sediment Removal at Sutter Bypass and Feather River Confluence	Measure consists of removal of sediment upstream from Nelson Slough rock weir.		X	This measure was dropped from further consideration because it would provide minor hydraulic benefit. The benefits would be temporary because this area would continue to have sediment deposition. This measure would result in high operations and maintenance costs, along with potential increased costs related to HTRW concerns.
S15	Southern Relief Structure	Construct relief structure in the levee at the south end of the Basin. If a levee were to fail upstream this downstream gate or fuse plug type feature would be used to convey floodwaters back the Feather River and Sutter Bypass channel In a levee breach scenario this may reduce peak stages in the southern portion resulting in less structures being flooded in the Yuba City area.	X		
S16	Modify Fremont Weir	Modify Fremont Weir to reduce stages in the study area.		X	This measure would not reduce the water surface elevations enough to reduce seepage under and through the levees nor address the stability issues.
S17	Reoperation of Oroville Dam & Reservoir (Feather River)	This measure seeks to offset approximately 100,000 acre-feet of water supply for flood control storage space in Oroville Reservoir.		X	This measure was dropped from further consideration because fixes to the existing levee would still be required. This measure provides limited benefits downstream. Other listed measures would provide more efficient means to achieve performance.
S18	Increased flood storage in Shasta and Black Butte Reservoirs upstream of Sutter Bypass	This measure seeks to offset approximately 1,460,000 acre-feet of water supply in Shasta Reservoir and 674,000 acre-feet in Black Butte Reservoir for flood control storage space.		X	Based on the Sacramento San Joaquin Comprehensive Study results, this measure was found to have almost no impact on flood stages in the study area.

S19	Authorized Marysville Reservoir (South Yuba River)	Marysville Reservoir is a USACE authorized project that has not been constructed. Marysville Reservoir would be located on the Yuba River just upstream of the City of Marysville and downstream from New Bullards Bar and Englebright dams.		X	This measure is considered cost-infeasible due to deep foundation problems.
S20	Feather River Dredging	This measure consists of dredging the Feather River from Oroville to the mouth of Sacramento River.		X	This measure was dropped from further consideration because it does not fix the under seepage problem occurring within the existing levee. This measure also results in high costs of ongoing operation and maintenance and land acquisition. In addition, there are environmental concerns with mercury and heavy metals.
S21	Modify pumps along Sutter Bypass	This measure seeks to reduce or eliminate flooding due to ponding of excess flood waters in the southwestern portion of the study area.		X	This measure was dropped from further consideration because it does not fit within the study objectives. The study objectives do not focus on interior drainage.
S22	Cherokee Canal Sediment Removal	This measure would remove sediment that may have accumulated in the Cherokee Canal.		X	This measure was dropped from further consideration because canal maintenance is the responsibility of another party. There are other ongoing efforts to address sediment removal in the Cherokee Canal.
S23	Sunset Weir Modification	This measure would modify a hydraulic structure in the Feather River that is used to divert water into an irrigation canal.	X		
S24	Gilsizer Cross Levee with flap gates	This measure would involve constructing a new levee across the Sutter Basin from Star Bend on the Feather River to Pumping Plant #2 on the Sutter Bypass. The areas to the north and south of the new levee would have different residual flood probability.	X		
S25	Wadsworth Canal Tributary Drainage	This measure would involve increasing the capacity of the Wadsworth Canal to accommodate additional runoff.	X		
S26	Managed overtopping (levee superiority) on Feather River and Sutter Bypass.	This measure would increase the resilience of the existing levee system by providing designated overtopping locations similar to spillways.	X		
S27	Improve upstream fish passage in Sutter Bypass. (Remove fish passage barriers). Dependent on S9	This measure would identify and remove fish passage barriers in the Sutter Bypass. This measure is dependent on measure S9.	X		
S28	Sutter Bypass Sediment Removal	This measure would remove sediment that may have accumulated in the Sutter Bypass.		X	This measure was dropped from further consideration because it is considered maintenance. Maintenance is the responsibility of another party.

S29	Vegetation Management in Sutter Bypass	This measure would manage vegetation that affects stages within the Sutter Bypass.		X	This measure was dropped from further consideration because it is considered maintenance. Maintenance is the responsibility of another party.
S30	Vegetation Management in Lower Feather River	This measure would manage vegetation that affects stages within the Lower Feather River.		X	This measure was dropped from further consideration because it is considered maintenance. Maintenance is the responsibility of another party.
S31	Vegetation Management in Upper Feather River	This measure would manage vegetation that affects stages within the Upper Feather River.		X	This measure was dropped from further consideration because it is considered maintenance. Maintenance is the responsibility of another party.
NS1	Relocate structures and critical infrastructure in floodplain.	This measure would include relocation of structures and critical infrastructure in floodplains.	X		
NS2	Floodproof at isolated locations.	Residential structures and other buildings would be evaluated for potential damages during flood events from water entering the structure. Floodproofing techniques would be selected on a case-by-case basis.	X		
NS3	Elevate structures and transportation infrastructure	This measure would include elevating structures, railroads, and highways.	X		
NS4	Establish flood-resistant housing	This measure would include construction of flood-resistant housing.	X		
NS5	Secure large floatable objects	Objects that might be mobilized and strike people during a flood event would be removed, relocated, or secured.	X		
NS6	Flood-warning system	This measure would involve developing, establishing, and implementing a system for warning the public about potential flood events.	X		
NS7	Evacuation plan	This measure involves coordination with local entities to establish and implement a plan for evacuation during a flood event.	X		
NS8	Construct ring levees at isolated locations	This measure would involve construction of ring levees around structures that are subject to damage from flood waters.	X		
NS9	Floodfight pre-staging equipment and supply area	This measure includes establishing designated sites within the study area for pre-staging floodfighting equipment and supplies.	X		
R1	Multi-Use Trails	Establish an interconnected multiuse trail system.	X		
R2	Bicycle Trails	Connect bike trails to a larger trail system, with a focus on Class 1 trails.	X		
R3	Equestrian Trails	Equestrian trails are designed for horses and their riders. They are typically separated from bike and pedestrian trails.	X		
R4	Day Use Area	Day use areas are staging or access points to recreation spaces that have	X		

		their own specific uses.			
R5	River Access	River access facilities allow the public to directly engage the water safely at controlled locations.	X		
R6	Scenic Overlook	This measure consists of wildlife viewing platforms and/or boardwalks on levees or flood risk management lands for bird watchers and wildlife enthusiasts separate from main trails.	X		
R7	Recreational parkway	This measure compliments the multi-use trail measure by preserving natural areas and wildlife habitat along the trail system.	X		

3.3 CONCEPTUAL ALTERNATIVES

Following the initial screening of measures, the team identified four themes (strategies) for plan formulation. The themes included the following: 1) Consequence Management Focused on Public Safety, 2) Urban FRM Focus, 3) Maximize Existing System with FRM Focus, and 4) Ecosystem Restoration Focus.

These themes were used to assist the team in establishing a preliminary array of conceptual alternatives by grouping measures according to the primary focus of each theme. Measures listed under each conceptual alternative were designated as either required measures or optional measures that could be incrementally added to the alternative. Based on the measures grouped under each theme, the team identified a total of nine conceptual alternatives. Aside from Alternative 1.1, all alternatives are comprised primarily of new levees or strengthening of existing levees. A matrix with the array of conceptual alternatives and measures associated with each of these alternatives is also included in Table 6. The nine conceptual alternatives are described below by theme. In addition to the nine conceptual alternatives, the No Action Alternative is described below.

Table 6. Themes and Conceptual Alternatives

ID	Management Measure	Theme 1: Consequence Management Focused on Public Safety	Alternative 1.1: Nonstructural	Theme 2: Urban FRM Focus	Alternative 2.1: Ring Levees	Alternative 2.2: Big J	Alternative 2.3: Little J	Alternative 2.4: Minimal Fix in Place	Alternative 2.5: Fix in Place Thermalito to Star Bend	Theme 3: Maximize Existing System with FRM Emphasis	Alternative 3.1: Fix in Place w/o Raising	Alternative 3.2: Fix in Place w/o Raising including Modest Setbacks	Theme 4: Ecosystem Emphasis	Alternative 4.1: Setbacks with Ecosystem Restoration
S1	Biggs Ring Levee			*	X									
S2	Gridley Ring Levee			*	X									
S3	Live Oak Ring Levee			*	X									
S4	Yuba City Ring Levee			*	X									
S5	Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend			*		X	X	X SBFCA segment 4 and 5 only (Sunset Weir to Shanghai Bend)	X	*	X May include sub reaches	X	*	X
S6	Southern Portion of J-Levee			*			X							
S7	Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee			* South to Star Bend only		X Feather River North of Star bend and Shanghai Bend north of Gilsizer slough		X Shanghai Bend to Star Bend	X Shanghai Bend to Star Bend	*	X May include sub reaches	X	* w/o Sutter Bypass fix in place	X w/o Sutter Bypass fix in place
S9	Sutter Bypass Setback Levee									*		O	*	X

S10	Northern Feather River Setback Levee			*						*		O	*	X
S11	Sutter Bypass and Feather River Confluence Setback Levee									*		X	*	X
S12	Star Bend Setback Levee			*		X			X	*	X	X	*	X
S13	Oroville DFG Wildlife Management Area – Degrade Land Surface and Restore Wetlands					O	O				O	O	*	X
S15	Southern Relief Structure	*	O	*						*	O	O	*	X
S23	Sunset Weir Modification			*		O	O	O		*	O	O	*	X
S24	Gilsizer Cross Levee with flap gates	*		*		X								
S25	Wadsworth Canal Tributary Drainage			*		O	O			*	O	O		
S26	Managed overtopping (levee superiority) on Feather River and Sutter Bypass.			*		O	O	O		*	O	O		
S27	Improve upstream fish passage in Sutter Bypass. (Remove fish passage barriers). Dependent on S9												*	X
NS1	Relocate structures and critical infrastructure in floodplain.	*	O	*	O	O	O	O	O	*	O	O	*	O
NS2	Floodproof at isolated locations.	*	O	*	O	O	O	O	O	*	O	O	*	O
NS3	Elevate structures and transportation infrastructure	*	O	*	O	O	O	O	O	*	O	O	*	O
NS4	Establish flood-resistant housing	*	O	*	O	O	O	O	O	*	O	O	*	O

NS5	Secure large floatable objects	*	O	*	O	O	O	O	O	*	O	O	*	O
NS6	Flood-warning system	*	X	*	X	X	X	X	X	*	X	X	*	X
NS7	Evacuation plan	*	X	*	X	X	X	X	X	*	X	X	*	X
NS8	Construct ring levees at isolated locations	*	O	*	O	O	O	O	O	*	O	O	*	O
NS9	Floodfight pre-staging equipment and supply area	*	X	*	X	X	X	X	X	*	X	X	*	X
R1	Multi-Use Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R2	Bicycle Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R3	Equestrian Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R4	Day Use Area	*	O	*	O	O	O	O	O	*	O	O	*	O
R5	River Access	*	O	*	O	O	O	O	O	*	O	O	*	O
R6	Scenic Overlook	*	O	*	O	O	O	O	O	*	O	O	*	O
R7	Recreational parkway	*	O	*	O	O	O	O	O	*	O	O	*	O

*: Included in theme
X: Included in alternative
O: Optional to alternative

3.3.1 Consequence Management Focused on Public Safety

3.3.1.1 Alternative 1.1: Nonstructural

At a minimum, the team determined that this alternative will include a flood warning system and evacuation plan. Optional measures include relocation of structures and critical infrastructure in the floodplain, floodproofing at isolated locations, elevating structures and transportation infrastructure, establishing flood-resistant housing, securing large floatable objects, constructing ring levees at isolated locations, and incorporating a southern relief structure. A map of this alternative is included as Plate 4. Only those measures with site specific locations are shown on Plate 4 and the plates for the other alternatives.

3.3.2 Urban FRM Focus

3.3.2.1 Alternative 2.1: Ring Levees

A map of this alternative including estimated residual floodplains is provided as Plate 5. This alternative consists of ring levees around the communities of Biggs, Gridley, Live Oak, and Yuba City. The heights of the Biggs, Gridley, and Live Oak ring levees were estimated based on the 0.2% (1/500) ACE levee breach inundation depths and an assumed additional height to provide 90% reliability. The height of the Yuba City ring levee was estimated based on the 0.5% (1/200) ACE levee breach floodplain and additional height to provide

90% reliability. The eastern flank of the Yuba City ring levee would utilize the existing Feather River levee. The existing levee would be strengthened in place to its existing authorized height with no raising and would meet current USACE design standards. The higher level of performance for the Biggs, Gridley, and Live Oak ring levees was utilized because the flood depths are relatively shallow and do not vary significantly between flood frequencies. Each ring levee was assumed to require a pump station to address interior drainage. The capacity of the pump station was based on the rational method.

3.3.2.2 Alternative 2.2: Big J

A map of this alternative including estimated residual floodplains is provided as Plate 6. This alternative includes strengthening the Feather River levees from Thermalito to Star Bend, constructing a new cross-levee from Star Bend to Gilsizer Slough, strengthening the Sutter Bypass levee from Gilsizer slough to Wadsworth canal, and strengthening the south levee of the Wadsworth canal. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising. The new levee reach was assumed to be a straight line profile from the Feather River levee to the Sutter Bypass levee. The levee footprint follows the approximate drainage divide to the two existing DWR pumping plants. Therefore, additional pumping plants would not be required. This alternative also includes the Star Bend setback levee.

3.3.2.3 Alternative 2.3: Little J

A map of this alternative including estimated residual floodplains is provided as Plate 7. This alternative includes strengthening in place Feather River levees from Thermalito to Shanghai Bend and constructing a new levee to the south and west of Yuba City. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising. The "J" levee was assumed to require a pump station to address interior drainage. The capacity of the pump station was based on the rational method.

3.3.2.4 Alternative 2.4: Minimal Fix-In-Place

A map of this alternative including estimated residual floodplains is provided as Plate 8. This alternative consists of strengthening in place the Feather River levees from Sunset Weir to Star Bend. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

3.3.2.5 Alternative 2.5: Fix-In-Place Thermalito to Star Bend

A map of this alternative including estimated residual floodplains is provided as Plate 9. This alternative consists of fixing in place Feather River levees from Thermalito to Star Bend and corresponds to phase 1 of the Feather River West Levee Project described in Section 1.4.1. The alternative also includes the Star Bend setback levee. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

3.3.3 Maximize Existing System with FRM Focus

3.3.3.1 Alternative 3.1: Fix-In-Place Without Raising

A map of this alternative including estimated residual floodplains is provided as Plate 10. This alternative consists of fixing in place the Feather River levees from Thermalito to the confluence with the Sutter Bypass and improving the east levees of the Sutter Bypass. . Levees along the south side of Wadsworth Canal would also be improved. The alternative also includes the Star Bend setback levee. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

3.3.3.2 Alternative 3.2: Primarily Fix-in-Place Including Modest Setbacks

A map of this alternative including estimated residual floodplains is provided as Plate 11. This alternative is similar to Alternative 3.1. However, in lieu of fixing in place the existing levees, new setback levees would be constructed at Northern Feather River and at the Sutter Bypass and Feather River confluence. The alternative also includes the Star Bend setback levee.

3.3.4 Ecosystem Restoration Focus

3.5.4.1 Alternative 4.1: Setbacks with Ecosystem Restoration

A map of this alternative including estimated residual floodplains is provided as Plate 12. This alternative is similar to Alternative 3.2. However, in lieu of improving the existing Sutter Bypass levee, a new setback levee would be constructed along the Sutter Bypass.

3.3.5 No Action Alternative

Under this alternative, the Federal government would take no action toward implementing a specific flood damage reduction plan. The study area would continue to be subject to risk of flooding and will rely on emergency responses to ensure the safety of local communities. Significant damage to property and potential loss of life could occur if the levees were to fail. Subsequent improvements to the levees would be done under emergency or post-failure conditions. Emergency costs associated with evacuation, flood fighting, fire and police, and government disruptions would occur. Transportation through the area could be severely hampered by a major flood, and critical infrastructure could be rendered nonfunctional for an extended period of time after a flood.

4.0 CONCEPTUAL DESIGN

Following the charette, each alternative was further developed at a class 4 level of detail based on civil design, hydrologic, hydraulic, geotechnical, and engineering considerations. Quantities, costs, and economic benefits were then estimated for each alternative.

4.1 LEVEE DESIGN

All levees within each alternative assume a design that meets current USACE standards for slopes (1V:3H waterside, 1:2H or 1V:3H landside existing or new slopes respectively), crest

width (20 ft), O&M access (10 ft existing minimum), and seepage and stability (0.5 exit gradient at the toe and 1.4 factor of safety for long term steady state stability). This includes both cases of new levees and modification of existing levees. The levees are considered to be capable of performance to the authorized design level for loading conditions. To achieve this performance, seepage control measures have been included in every alternative based on a parametric approach.

The parametric levee design approach utilized a suite of nine levee cross section (referred to as templates; refer to Plate X) that represent typical design configurations applicable to the study area. The parametric templates include:

- Stability Berm Element
- Stability Berm with Relief Wells Element
- Seepage Berm Element
- Gravel Stability Berm Element
- Waterside Soil-Bentonite Cutoff Wall Element
- Centerline Soil-Bentonite Slurry Cutoff Wall Element
- New Levee Element
- New Levee with Centerline Soil-Bentonite Cutoff Wall Element
- Levee Crest Widening Element

Not every possible seepage control or stability mitigation measure was included at this level of detail. Soil-bentonite cutoff walls are assumed at this level of design, though at subsequent design level, a seepage berm or some other measure (e.g. relief fells, etc.) may be required. This was done for simplicity, given the low level of information available, and because soil-bentonite walls have a lower impact to the environment.

A set of applicable templates was assigned to each reach based on a review of the conditions. Each template was then specified as a percentage of overall reach length. For example, a reach might include 20% soil bentonite slurry wall template and 90% levee crest widening template (note that the totals can be more than 100%, even for seepage control measures). The basic parameters that define each template were then specified based on an assessment of the existing performance of the levee within each reach.

Parametric templates were specified to meet current USACE geotechnical design requirements. Cutoff walls were typically specified for levee strengthening instead of seepage berms. For new levees, it is more cost effective to construct a cutoff wall than a seepage berm. In general, seepage berms and cutoff walls are roughly the same overall cost (considering real estate acquisition, and the increasing number of local contractors capable of cutoff wall construction), but seepage berms usually have a higher impact to the environment during construction

Proposed seepage control measures, including type (berm, cutoff wall, etc.), sizing (depth, width, etc.) and length (or percentage of length) were based on the existing condition report, and augmented by professional judgment and specific local knowledge, and/ or geological and soil maps.

The alignment of new levees was refined following the charette. Alignments were based on a review of aerial photography and topographic features. Geographic placement was based on minimizing impacts to existing structures, environmentally sensitive areas, and features expected to require costly mitigation or relocation. The objective was to maximize FRM benefits to existing structures while minimizing the length (cost) of the new levee.

Geotechnical design template parameters for seepage control measures were based on "expected" or median values. Judgment was used to estimate the minimum and maximum possible values, followed by an assumption of a median value. For instance, a ring levee far from the river was assumed to require a cutoff wall for some portion of the ring, and the lowest possible value that was expected based on engineering judgment was selected (for instance 25%). Next, the highest possible value was estimated (for instance 75%). The same approach was used for het depth of the cutoff wall. Finally, based on engineering experience the "expected" value was estimated to lie between these extreme values. Note that the median value was not necessarily a conservative value, nor was it the "mean" value.

The current authorized height was used for the design height of existing levees. An increase to the currently authorized levee design height was not considered due to possible adverse hydraulic impacts to floodplains outside of the study area. The design height of new levees was based on modeled floodplain water surface elevations and additional estimated height to provide 90% confidence The water surface elevation was based on a worst case breach of any levees outside the strengthened reaches identified in the alternative. As previously indicated, design of existing levees was assumed to provide performance to the authorized design elevation. No range of evaluations for different loading conditions was developed, because past protect experience indicates that any modification at all provides improvement of the project to the design elevation, leaving segments of high and low level of performance, which does not provide a systematic approach. An assessment of large relocations (road and canal/ditch crossings) was based on visual inspection of aerial imagery. Relocations were tabulated based on common characteristics such as road crossings, flood gates, bridges, and closure structures.

Real estate and structure relocations were developed for each alternative based on estimated rights-of-way. Acreage was calculated using the levee template parameters within each reach.

Additional features necessary to meet current USACE standards were tabulated by levee reach. Examples of additional features include utility penetrations, drainage culverts, and pipelines. The additional features were estimated from levee logs recently completed by DWR.

4.2 COST ESTIMATES

Cost estimates were completed for each alternative. Quantities for levee improvements were developed from the levee design templates and levee logs. Quantities for relocations, additional non-levee features, and real estate were developed primarily from assessment of aerial imagery.

A spreadsheet developed by URS Corporation was used to prepare cost estimates for the levee improvements and new levees. This spreadsheet estimates costs based on a parametric approach. The spreadsheet calculates the cost based on the design cross section templates and typical parameters within the reach (levee top width, height, etc.). The spreadsheet utilizes a database of

unit price data from public bid results and projects that URS worked on for DWR and other public agencies. Unit prices in the spreadsheet were reviewed and updated to reflect present costs. For each levee reach and selected design template, the design parameters and quantities provided by USACE civil and geotechnical engineers were utilized to generate the cost estimate.

Other major cost items including roads, railroads and canals crossing new levees, utility relocations, interior drainage, traffic control, Storm Water Pollution Prevention Plan and erosion control, cultural resources, and fish and wildlife mitigation, along with corresponding project costs for Planning, Engineering & Design (PED), and Construction Management were considered separately. The costs for work relative to obstructions and structures crossing levees (special items) and interior drainage (pump stations) were based on preliminary quantity take-offs, hydrological analysis, existing cost data for similar projects, and historic cost estimates for projects with similar work. A percentage of the construction costs was used to compute costs for the other major cost items.

Real estate land costs were estimated using the parametric spreadsheet described above. The spreadsheet multiplies the estimated footprint area by the percentage of land in four typical categories found within the study area. The four categories included agricultural, residential, commercial, and orchard. The percentage of land within each category was based on a review of the linear distribution in recent aerial photography. The approximate land costs of each category were based on a range of values (high and low) provided by the appraisal section. The costs included in the parametric spreadsheet were based on the average of the high and low values within each category.

Real estate administration costs required to acquire a portion of a parcel or entire parcel by the non Federal sponsor include securing rights of entry for engineering and environmental surveys, topographic mapping, surveying existing levee toes, surveying existing roadways for Plats and Legal Descriptions, right of way field staking, appraisal services, Independent Appraisal Review, acquisition services, relocation assistance program, title and escrow support, and condemnation support if needed. Report development and future land crediting activities are also federal administrative costs required as part of the cost estimate.

Real estate administration costs were estimated by multiplying the estimated number of parcels within the levee footprint by a typical administration cost. Administrative costs were estimated to be $85,000 per parcel for new levees and $60,000 per parcel for existing levees. Administrative costs were assumed be less for existing levees because they are likely to be within an existing right-of-way. The costs were estimated based on historical Corps projects. Actual values would vary significantly because each parcel is unique. Major factors affecting this cost include willing seller, no willing seller and potential condemnation. Relocation costs for displaced residents or businesses as addressed in P.L. 91-646 (Uniform Relocation Assistance and Real Property Acquisition Policies Act) are not included, but will be determined as the array is refined..

The total estimated cost for each alternative is the summation of the costs from the parametric spreadsheet output, the costs developed for special items and interior drainage, and the costs of the other major cost items (as a percentage of construction cost).

4.3 WITH PROJECT FLOODPLAINS

With project residual floodplains were estimated for each alternative. The floodplains were estimated assuming levee heights would be sufficient to provide 90% reliability for the design flood. The floodplains for the with project conditions were estimated using the modeled breaches under existing conditions. For the fix in place alternatives, this was accomplished by only including breaches in the unimproved levee reaches. For the Ring and J-Levee alternatives, the existing condition breach maps were modified to remove the portions on the land side of the ring and J-levee.

4.4 ECONOMIC BENEFITS

Economic benefits were estimated for each alternative. The first step was to estimate the maximum economic benefit of fixing all levees to their design height. For each alternative, the benefit was estimated by applying a ratio based on the without and with project floodplains. The intent of the use of these results is solely to screen out those preliminary alternatives that do not appear economically justified even in the most favorable benefit/cost ratio ranges. Table 7 provides an economic comparison of the alternatives.

Table 7. Economic Comparison

Alternative	Total First Cost ($Millions)		Estimated Annual Net Benefits ($Millions)		Estimated Benefit to Cost Ratio	
	Low	High	Low	High	Low	High
1.1 - Nonstructural	TBD	TBD	TBD	TBD	TBD	TBD
2.1 - Ring Levees						
Yuba City	313	671	-10	29	0.4	3.2
Gridley	95	204	-6	0	0.1	0.9
Live Oak	82	177	-5	0	0.1	0.9
Biggs	60	129	-5	-2	0.0	0.3
2.2 - Big J	703	1,506	-35	26	0.2	1.9
2.3 - Little J	560	1,201	-24	32	0.3	2.4
2.4 - Minimal Fix- in -Place	177	381	-8	9	0.3	2.3
2.5 - Fix in Place Thermalito to Star Bend	422	905	-17	29	0.3	2.7
3.1 - Fix in Place w/o Raising	737	1,579	-36	29	0.2	2.0
3.2 Primarily Fix in Place including modest setbacks	882	1,900	-48	22	0.2	1.6
4.1 Setbacks with Ecosystem Restoration	1,543	3,308	-100	-3	0.1	0.9

5.0 ALTERNATIVE REFINEMENT

A combined Value Engineering (VE) Study and Planning Charette was held from 31 October to 4 November 2011. The VE methodology was incorporated into the planning process at an early stage of the study to compare, refine, and optimize alternatives based on multiple criteria in order to ensure a robust array. This process also provided an opportunity to validate the array of preliminary alternatives and to ensure that significant alternatives had not been overlooked. The

VE Study/Charette was attended by the PDT and non-Federal sponsors, the SPK VE Officer and SPD VE Program Manager, the SPD Plan Formulation Lead, and representatives from the National Pilot Program 17+1 Team. The team reviewed initial alternative evaluation criteria and expanded these criteria based on input from the group. Following are the final criteria that were used to assess each alternative in combination with the conceptual level cost estimates for each alternative.

5.1 VE STUDY/CHARETTE EVALUATION CRITERIA

5.1.1 Life Safety

This criterion focuses on the potential for life safety risk including the potential for the loss of human life and immediate health impacts that result from flood conditions as well as to facilities such as medical—hospitals, critical care units, helipads for medical; concentrated overnight places– nursing homes, motels; administrative coordination and assistance facilities. It also includes an assessment of the ability to maintain evacuation routes such as road systems leaving major population centers during flood events. Levees with lower geotechnical performance (higher probability of failure prior to overtopping) were considered to have higher life safety risk due to unexpected failure. A qualitative assessment of life safety was also conducted during the VE study.

5.1.2 Flood Damage Benefits

This criterion focuses on flood damage benefits which account for the reduction of flood damages to property. Property includes, for example, buildings, economic assets, and loss of standing crops and livestock in agriculture. Each alternative was qualitatively rated based on the geographic distribution of damageable property and the estimated 1% (1/100), 0.5% (1/200), and 0.2% (1/500) ACE residual floodplains for the alternative.

5.1.3 Critical Infrastructure Impacts

This criterion focuses on the potential for impacts to critical infrastructure such as power plants; transportation– road, rail, and air; power– energy supply and distribution systems, including oil; communications– telecommunications network including; public health services– regional healthcare facilities; and water supply and treatment facilities.

5.1.4 Design Capacity Exceedance

Design capacity exceedance measures the remaining flood risks after project measures are constructed that are above and beyond those risks being addressed by the project. This criterion also considers the issue of levee superiority to manage residual risk of catastrophic failures and measures the consequences to life and property if a given alternative's design is exceeded.

5.1.5 Wise Use of Floodplain (Minimize Growth Inducement in Floodplain)

This criterion considers the characteristics of the alternative which could encourage or facilitate growth in the floodplain in an unwise manner. Each alternative was qualitatively rated based on the degree to which the alternative would discourage development in the most high risk areas of the floodplain.

5.1.6 Sustainability

This criterion is a measure of the extent to which future funds and effort will be required to sustain the project measures provided. It is defined as developing and protecting the constructed measures in a manner that enables people to meet current needs and provides that future generations can also meet future needs, from the joint perspective of environmental, economic and community objectives.

5.1.7 Ecosystem Functionality

Ecosystem functionality is a measure of the project's ability to maintain or enhance the natural environment to support a functioning ecosystem. This criterion includes an assessment of the opportunities for riparian and wetland habitat preservation and restoration as well as the efforts to minimize impacts to environmentally sensitive areas adjacent to floodplain such as the riparian forest, oak woodland, and giant garter snake habitats . The criterion also considers the restoration or preservation of natural riverine processes in the floodplain. A wider river channel would also contribute to improvements in fish habitat. Alternatives should restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities.

In order to assess ecosystem functionality associated with each of the alternatives, the team identified areas for potential ER, in conjunction with FRM, by reviewing aerial photography, coordinating with the local sponsor, and reviewing existing reports. Primary information sources included the draft *Sutter Basin Feasibility Study Environmental Without-Project Conditions Report* (ICF International 2011), *Pre-Design Formulation Report Sutter Butte Flood Control Agency Feather River West Levee Project* (HDR, MHM, URS, & Wood Rodgers, 2011), and *Sutter Basin Feasibility Study Restoration Opportunities, Measures, and Sponsors* (ICF International, 2010).

5.1.8 Environmental Impacts

This criterion focuses on the project's temporary and permanent impacts to the environment. It includes the preservation of the existing floodplain and avoiding adverse effects on air quality, water quality, and other resources. Land disturbance outside the existing levee footprint should be minimized. The criterion also considers the loss of farmland and impacts to existing structures.

In order to identify sensitive habitat and qualitatively assess potential environmental impacts associated with each of the alternatives, the team reviewed available information from various databases and existing reports. Primary information sources included the draft *Sutter Basin Feasibility Study Environmental Without-Project Conditions Report* (ICF International, 2011) and the *Environmental Constraints Analysis for the Feather River West Levee Project* (ICF International, 2011). The team also reviewed the *Environmental Site Assessment, Sutter Basin*

Pilot Study Preliminary Assessment of Alternatives report (USACE, 2011) to assess potential HTRW issues associated with each of the alternatives.

5.2 VE STUDY/CHARETTE ALTERNATIVE EVALUATION

During the VE Study/Charette, each preliminary alternative was qualitatively rated on a relative scale of 1 (worst) to 10 (best) based on the criteria presented in Section 2.2. A discussion of each alternative in relation to these criteria is provided below. The VE Study/Charette Report, which includes more details on the relative ratings of each alternative and the evaluation process, is included in Appendix B.

Since the measures to be included in the nonstructural alternative have not yet been well defined, this alternative was not evaluated during the combined VE Study/Charette. However, the team qualitatively evaluated the alternative following the VE Study/Charette. The results of this evaluation are discussed below. By policy, a primarily nonstructural alternative will be included in the final array.

5.2.1 Nonstructural Alternative

5.2.1.1 Cost

In order to assess flood damage benefits, the team needs to refine the nonstructural alternative and calculate the costs of the measures that would comprise the nonstructural alternative.

5.2.1.2 Life Safety

Risk of geotechnical levee failure and subsequent flooding in the surrounding area would remain. Subsequent improvements to the levee would be done under emergency or post-failure conditions.

5.2.1.3 Flood Damage Benefits

In order to assess flood damage benefits, the team needs to refine the nonstructural alternative and calculate the benefits of the measures that would comprise the nonstructural alternative.

5.2.1.4 Critical Infrastructure Impacts

At a minimum, measure NS6 (flood warning system) and measure NS7 (evacuation plan) will be included in this alternative. These measures would not address impacts to critical infrastructure. In order to assess critical infrastructure impacts, the team needs to refine the nonstructural alternative.

5.2.1.5 Design Capacity Exceedance

In order to assess design capacity exceedance, the team needs to determine what other measures would be included in the nonstructural alternative in addition to measure NS6 (flood warning system) and measure NS7 (evacuation plan).

5.2.1.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would likely limit growth of local communities and future regional growth.

5.2.1.7 Sustainability

In order to assess sustainability, the team needs to refine the nonstructural alternative.

5.2.1.8 Ecosystem Functionality

If measure NS1 is included in this alternative, structure removal and relocation could provide an opportunity for ecosystem restoration benefits through riparian/wetland habitat restoration and creation of open space.

5.2.1.9 Environmental Impacts

This alternative may have the least direct environmental impact compared to the other alternatives because it would involve the least amount of construction activity and would minimizes the potential for future growth. However, communities and historic structures could be impacted by certain nonstructural measures such as NS1 (relocation of structures and critical infrastructure in the floodplain), NS2 (floodproofing at isolated locations), and NS3 (elevating structures and transportation infrastructure).

5.2.2 Ring Levees Alternative

5.2.2.1 Cost

The total estimated first cost of this alternative is $582 to 1,248 million. A breakdown of approximate first cost for each ring levee is provided below:

- Measure S1 (Biggs Ring Levee): $60 to $129 million
- Measure S2 (Gridley Ring Levee): $95 to $204 million
- Measure S3 (Live Oak Ring Levee): $82 to $177 million
- Measure S4 (Yuba City Ring Levee): $313 to $671 million

5.2.2.2 Life Safety

This alternative would reduce flood risk for a majority of the concentrated population and property within Yuba City, Live Oak, Gridley, and Biggs. Locations outside of the ring

levees (non-urban areas) would not receive flood reduction benefits from the ring levees. However, these areas are relatively low in population density. The ring levee around Yuba City would include a reach of the Feather River levee system. Thus, there would only be one line of protection around Yuba City versus two lines of protection provided by the ring levees of the other communities. A drawback of this alternative is that ring levees would rely on flood gates and other measures at crossings with railroads and roadways that would need to be actively operated in order to be effective. This alternative would also require access to evacuation routes. An evacuation plan would be included as a nonstructural measure for this alternative to address life safety.

5.2.2.3 Flood Damage Benefits

This alternative provides flood risk reduction to key urban development areas, thus property damages from flood events would be minimized. The ring levees around the four urbanized communities would reduce the flood risk for much of the property within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. A breakdown of the estimated annual net benefits for each ring levee is provided below. Based on this breakdown, Yuba City is the only potentially economically justified increment.

- Measure S1 (Biggs Ring Levee): $-5 to $-2 million
- Measure S2 (Gridley Ring Levee): $-6 to $0 million
- Measure S3 (Live Oak Ring Levee): $-5 to $0 million
- Measure S4 (Yuba City Ring Levee): $-10 to $29 million

5.2.2.4 Critical Infrastructure Impacts

Ring levees would reduce flood risk for key regional facilities and other critical infrastructure within the ring levees, but would not reduce the risk of flooding of roadways and railroads outside of the ring levees.

5.2.2.5 Design Capacity Exceedance

If design capacity was exceeded, the interior of the ring levees would flood rapidly, which could result in loss of life. In addition, the ring levee around Yuba City would include a reach that is part of the Feather River levee system. Thus, there would be only one line of protection for Yuba City versus two layers from the ring levees of the other three communities.

5.2.2.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would limit growth of local communities and future regional growth, while allowing in-fill and redevelopment within the existing developed area.

5.2.2.7 Sustainability

This alternative would require maintenance of pump stations and closure structures to ensure effective continued operation and flood risk management for the ring levees. In addition, this alternative would require maintaining the existing levees within the study area, which are currently at risk of failure due to through-seepage and underseepage. Maintenance of new ring levees would also be required. However, the maintenance requirements of new levees would be less than existing levees because they would be constructed on new foundations and to modern engineering standards.

5.2.2.8 Ecosystem Functionality

Opportunities may exist for ecosystem restoration near the reaches of levee at Yuba City that would be incorporated into the Yuba City ring levee. There are few opportunities for ecosystem restoration associated with the other ring levee locations. Constructing new ring levees may impact existing functionality.

5.2.2.9 Environmental Impacts

This alternative preserves the existing floodplain while minimizing the potential for future growth and associated adverse effects on air quality and other resources. However, this alternative has the potential to conflict with local land use plans. Construction of the ring levees would require multiple railroad crossings as well as crossings of two significant drainage canals in Yuba City. Significant borrow material would be required for construction of the new levees. Direct and indirect impacts associated with this alternative could affect environmentally and culturally sensitive areas. In addition, construction of the levees would occur in urban areas that are more susceptible to air and noise quality impacts. Ring levees would also separate the communities of Yuba City, Live Oak, Gridley, and Biggs from their surrounding supporting areas and would result in aesthetic impacts by disrupting existing viewsheds. Pump stations would have to be operated periodically, which may result in air quality and noise impacts. There may also be HTRW issues associated with new levee alignments.

5.2.3 Big "J" Alternative

5.2.3.1 Cost

The total estimated first cost of this alternative is $703 to $1,506 million.

5.2.3.2 Life Safety

This alternative would reduce flood risk to the majority of the population and property within the study area. Areas in the southern portion of the study located below the Big "J" cross-levee would be located within the 1% (1/100)ACE floodplain. No actively operated closures would be necessary to maintain this alternative. All existing evacuation routes would be maintained.

5.2.3.3 Flood Damage Benefits

This alternative would capture approximately 93% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. The benefits would be limited by the performance of the Sutter Bypass levees, which have a lower performance than the Feather River levees. As presented in Table 7, the estimated annual net benefits for this alternative range from $-35 to $26 million.

5.2.3.4 Critical Infrastructure Impacts

This alternative would provide flood risk reduction for hospitals, power plants, and other critical infrastructure within the study area, but would not reduce risk for all critical roadways within study area limits.

5.2.3.5 Design Capacity Exceedance

If design capacity was exceeded, the evacuation route on westbound Route 20 would be impacted. If the levee failed, flood depths would be greater due to the height of the southern cross levee south of Yuba City. The flood depths within the urbanized area of Yuba City would increase at a faster rate due to changes in the location of floodplain storage. Areas in the southern portion of the study area (below Sutter Bypass levee) would remain at high risk to flooding.

5.2.3.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative reduces flood risk in Yuba City and other communities, which would allow for growth in existing urbanized areas. The cost of complying with the floodplain regulations could limit growth in the study area outside the Big J levee.

5.2.3.7 Sustainability

This alternative would result in reduced maintenance on the majority of existing levees along the Feather River, which are currently at risk of failure due to through-seepage and underseepage. New cross-levees for this alternative would be constructed on new foundations and to modern engineering standards. In addition to the maintenance required for the existing levees, these new reaches would require additional maintenance.

5.2.3.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration within the segments of this alternative that includes existing levees. There are few opportunities for ecosystem restoration on other segments of this alternative. Constructing cross-levees may invade existing functioning ecosystems. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.3.9 Environmental Impacts

Construction of the new cross levee associated with this alternative would directly impact farmland and potential sensitive habitat areas. Construction impacts would be limited where land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. The alternative would significant borrow material to construct new levee reaches. Construction of cutoff walls could potentially disrupt groundwater flows. Potential HTRW issues exist for new levee alignments. The alternative would include construction of levee reaches in urban areas, which are more susceptible to air and noise quality impacts. These new levee reaches would result in aesthetic impacts by disrupting existing viewsheds. This alternative would also separate the agricultural areas in the southern portion of the study area from the communities located in the northern portion.

5.2.4 Little "J" Alternative

5.2.4.1 Cost

The total estimated first cost of this alternative is $560 to $1,201 million.

5.2.4.2 Life Safety

This alternative would reduce flood risk to the majority of the population and property within the study area due to the population density in Yuba City. Areas in the southern portion of the study located below the Little "J" cross-levee would remain at risk of flooding. This alternative would impact the evacuation route on westbound Route 20 and two major drainage areas in Yuba City.

5.2.4.3 Flood Damage Benefits

This alternative would capture approximately 93% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As shown in Table 7, the estimated annual net benefits for this alternative range from $-24 to $32 million.

5.2.4.4 Critical Infrastructure Impacts

This alternative reduces the risk of flooding for hospitals, power plants, and other critical infrastructure within the study area, but does not reduce risk for certain roadways within project limits.

5.2.4.5 Design Capacity Exceedance

If design capacity was exceeded, the evacuation route on westbound Route 20 and two major drainage areas in Yuba City would be impacted. Areas in the southern portion of the study area (below Sutter Bypass levee) would remain at risk to flood. The area north of the Little "J" levee would capture flood waters from the breach resulting in greater depths and faster stage increases.

5.2.4.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative reduces flood risk in Yuba City and other communities, which would allow for growth in existing urbanized areas. It provides limited flood risk reduction in all other parts of the study area, which could limit future growth. It focuses development in areas designated or already developed in lieu of encouraging development scattered through floodplain.

5.2.4.7 Sustainability

This alternative would result in reduced maintenance on the majority of existing levees along the Feather River, which are currently at risk of failure due to through-seepage and underseepage. New levees for this alternative would be constructed on new foundations and to current engineering standards. In addition to the maintenance required for the existing levees, the new levee reaches would require additional maintenance. This alternative would also require maintenance of pump stations and closure structures to ensure effective continued operation and flood risk management.

5.2.4.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration within the reaches of this alternative that include existing levees. There are few opportunities for ecosystem restoration on other reaches of this alternative. Constructing new levees may invade existing functioning ecosystems. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.4.9 Environmental Impacts

Construction of the new levee associated with this alternative would directly impact farmland and potential sensitive habitat areas. Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. The alternative would also require crossing two significant drainage systems in Yuba City and significant borrow material to construct levee reaches. Construction of cutoff walls could potentially disrupt groundwater flows. Potential HTRW issues exist for new levee alignments. The alternative would include construction of levee reaches near urban areas, which are more susceptible to air and noise quality impacts. These new levee reaches would result in aesthetic impacts by disrupting existing viewsheds. This alternative would also

separate the agricultural areas in the southern portion of the study area from the communities located in the northern portion.

5.2.5 Minimal Fix-In-Place Alternative

5.2.5.1 Cost

The total estimated first cost of this alternative is $177 to $381 million.

5.2.5.2 Life Safety

This alternative would reduce flood risk to portions of Yuba City and surrounding areas, but would not reduce flood risk for the communities in the northern study area (Live Oak, Gridley, and Biggs) and some portions of Yuba City. This alternative addresses high life risk areas south of the Yuba River and Feather River confluence and in Yuba City. In the event of flooding, the eastbound SR-20 evacuation route would be accessible, but evacuation routes SR-99 and Westbound SR-20 would be cut off.

5.2.5.3 Flood Damage Benefits

This alternative would provide flood risk reduction to approximately half of Yuba City, which includes approximately 77% of the total property within the study area. It would provide some protection to agricultural lands. The alternative would capture approximately 39% of total benefits within the study area. Compared to the other structural alternatives, it would provide the least amount of flood risk reduction and expose the maximum amount of property to potential damage. As presented in Table 7, the estimated annual net benefits for this alternative range from $-8 to $9 million.

5.2.5.4 Critical Infrastructure Impacts

The alternative would not provide flood risk reduction for all key critical infrastructure (hospitals, power plants) and would not provide flood risk reduction for roadways or railroads within the study area.

5.2.5.5 Design Capacity Exceedance

Given the limited extent of levee improvements, it is anticipated that design capacity would be exceeded on a frequent basis. In the event of flooding, the eastbound SR-20 evacuation route would be accessible, but evacuation routes SR-99 and Westbound SR-20 would be cut off. The alternative would not result in the ponding issues caused by the cross-levees in the J-levee alternatives.

5.2.5.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative reduces flood risk in approximately half of Yuba City. It does not provide flood risk reduction in all other parts of the study area, which could limit future growth.

5.2.5.7 Sustainability

Compared to the other structural alternatives, this alternative would result in the minimum amount of existing levees being improved. Thus, maintenance efforts for existing levees would be greater as compared to the other alternatives. However, the alternative would not add any additional reaches of levees to be maintained.

5.2.5.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.5.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

5.2.6 Fix-In-Place Thermalito to Star Bend Alternative

5.2.6.1 Cost

The total estimated first cost of this alternative is $422 to $905.

5.2.6.2 Life Safety

This alternative is estimated to provide a 0.5% (1/200) ACE with 90% assurance level of flood risk reduction to a majority of the northern areas and communities within the study area, including Yuba City. It would not provide flood risk reduction from an event in the western portion of the study area. This alternative would preserve eastbound SR-20 as an evacuation route, but would cut off SR-20 westbound and SR-113 as evacuation routes.

5.2.6.3 Flood Damage Benefits

The alternative would capture approximately 79% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As shown in Table 7, the estimated annual net benefits range from $-17 to $29 million.

5.2.6.4 Critical Infrastructure Impacts

This alternative would reduce risk for the majority of hospitals, power plants, and other critical infrastructure within the study area, but would not reduce risk for all roadways.

5.2.6.5 Design Capacity Exceedance

It is anticipated that design capacity of unimproved reaches would be exceeded on a frequent basis. However, the levees along the northern segments of the Feather River would be improved and the probability of potential breaches would decrease. This alternative would preserve eastbound SR-20, but would cut off SR-20 westbound and SR-113 as evacuation routes. The alternative would not result in the ponding issues caused by the new levees in the J-levee alternatives. However, deep ponding in the southern portion of the study area would exist.

5.2.6.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development in these areas. By reducing risk to the existing urbanized areas, it focuses development in areas designated or already developed in lieu of encouraging development scattered through the floodplain.

5.2.6.7 Sustainability

This alternative would improve reaches of existing levees that currently have issues related to underseepage and through-seepage, thus reducing maintenance requirements. The alternative would not add any additional levees to be maintained. The Sutter Bypass levees and Feather River levees below Star Bend would not be improved and maintenance requirements are anticipated to remain the same.

5.2.6.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.6.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

5.2.7 Fix-In-Place Without Raising Alternative

5.2.7.1 Cost

The total estimated first cost of this alternative is $737 to $1,579 million.

5.2.7.2 Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes.

5.2.7.3 Flood Damage Benefits

The alternative would capture most of the total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As presented in Table 7, the estimated annual net benefits range from $-36 to $29 million.

5.2.7.4 Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

5.2.7.5 Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. Flooding from an event that exceeded the design capacity would be similar to the existing (without-project condition). This alternative would preserve SR-20 and SR-113 as evacuation routes.

5.2.7.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

5.2.7.7 Sustainability

This alternative would improve the majority of reaches of existing levees, thus reducing maintenance requirements. The alternative would not add any additional levees to be maintained.

5.2.7.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.7.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

5.2.8 Primarily Fix-In-Place With Modest Setbacks Alternative

5.2.8.1 Cost

The total estimated first cost of this alternative is $882 to $1,900 million.

5.2.8.2 Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. This alternative would preserve SR-20 and SR-113 as evacuation routes. There would be a marginal factor of safety improvements due to setback levees being built on new foundations.

5.2.8.3 Flood Damage Benefits

The alternative would capture almost 100% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As presented in Table 7, the estimated annual net benefits for this alternative vary from $-48 to $22 million.

5.2.8.4 Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

5.2.8.5 Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. It would not create the ponding issue that would be caused by the cross-levees of the Big "J" and Little "J" alternatives and would provide more area for ponding in the southern portion of the study area. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. There would be a marginal factor of safety improvement due to setback levees being built on new foundations.

5.2.8.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would provide 1% (1/100) ACE with 90% assurance flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

5.2.8.7 Sustainability

This alternative would improve the majority of reaches of existing levees, thus reducing maintenance requirements. Setback levees would be constructed on new foundations and to latest engineering standards, thus reducing maintenance efforts. Setback levees would have access points and distances to allow maintenance vehicles access.

5.2.8.8 Ecosystem Functionality

Levee setbacks would create opportunities for restoration of riparian and wetland habitats within the setback areas (approximately 700 acres). A wider river channel would contribute to improvements in fish habitats.

5.2.8.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows. Where setback levees are proposed, construction may require removal or relocation of structures and include conversion of farmland to upland, riparian or wetland habitats.

5.2.9 Setbacks With Ecosystem Restoration Alternative

5.2.9.1 Cost

The total estimated first cost of this alternative is $1,543 to $3,308 million.

5.2.9.2 Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. It would reduce flood risk for most of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. Setback levees would reduce the water surface elevation. There would be a marginal factor of safety improvement due to setback levees being built on new foundations.

5.2.9.3 Flood Damage Benefits

The alternative would capture almost 100% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As shown in Table 7, the estimated annual net benefits for this alternative range from $-100 to $-3 million.

5.2.9.4 Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

5.2.9.5 Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. It would not create the ponding issue that would be caused by the cross-levees of the Big "J" and Little "J" alternatives and would provide more area for ponding in the southern portion of the study area. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. Setback levees would allow levees to withstand erosion during design exceedance better than fixing the existing levees in place.

5.2.9.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

5.2.9.7 Sustainability

This alternative would improve the majority of existing levees, thus reducing maintenance requirements. Setback levees would be constructed on new foundations and to latest engineering standards, thus reducing maintenance efforts. Setback levees would have access points and distances to allow maintenance vehicles access.

5.2.9.8 Ecosystem Functionality

Levee setbacks would create opportunities for restoration of riparian and wetland habitats within the setback areas (approximately 4,100 acres). A wider river channel would contribute to improvements in fish habitats.

5.2.9.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows. Where setback levees are proposed, construction may require removal or relocation of structures and include conversion of farmland to upland, riparian, and wetlands habitats.

5.3 VE STUDY/CHARETTE RESULTS

Based on the discussions during the combined VE Study/Charette, the team identified alternatives with very similar functions as well as alternatives with little probability of implementation. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array. Following is a summary of the recommendations for the array of alternatives to be carried forward.

The existing measures establishing a flood-warning system and evacuation plan, as well as a new measure establishing floodfight pre-staging equipment and supply areas, should be the first added increments to all alternatives.

It was decided that a purely non-structural alternative was not likely feasible due to the extent and depths of probable floods. The team recommended combining Alternative 1.1 (Nonstructural) and Alternative 2.4 (Minimal Fix-In-Place) into a new alternative titled "Minimal Fix-in-Place plus Non-Structural" that would reduce residual risk. This alternative is a combination of minimal levee improvements to Feather River levees with the implementation of nonstructural measures focused on reducing risk to loss of life. A map of this alternative is provided as Plate 13.

The team determined that the costs of constructing ring levees around Biggs, Gridley, and Live Oak are significantly greater than the estimated annual benefits could support. Therefore, Alternative 2.1 (Ring Levees) should be refined by eliminating the individual ring levees around Biggs, Gridley, and Live Oak. This new alternative is titled "Yuba City Ring Levee" and consists of constructing a ring levee around Yuba City in combination with nonstructural measures focused on reducing risk in areas outside of the ring levee. A map of this alternative is provided as Plate 14.

The team recommended that Alternative 2.2 (Big "J" levee) be eliminated from further evaluation and that Alternative 2.3 (Little "J" levee) be retained. The Big "J" levee and the Little "J" levee are very functionally similar and are expected to have similar flood damage benefits. However, the Big "J" levee would be approximately 30% greater in cost based on conceptual cost estimates. In addition, if the design capacity of the Sutter Bypass reach of the Big "J" levee was exceeded, flood depths would be greater than existing conditions due to the height of the southern cross portion of the "J" levee (south of Yuba City). The flood depths would also increase at a faster rate due to less floodplain storage. Finally, the benefits associated with the Big "J" levee would be limited by the performance of the Sutter Bypass levees, which have a lower performance than the Feather River levees. The Little "J" levee does not utilize the Sutter Bypass levees and can therefore obtain a higher level of performance. A map of the Little "J" levee alternative is provided as Plate 15.

Based on an assessment of Alternative 2.5 (Fix-In-Place Thermalito to Star Bend) in relation to the evaluation criteria utilized for the combined VE Study/Charette, it was determined that this alternative should be retained. A map of the Fix-In-Place from Thermalito to Star Bend alternative is provided as Plate 16.

The team recommended that Alternative 3.1 (Fix-In-Place Without Raising) should be combined with Alternative 3.2 (Primarily Fix-In-Place with Modest Setbacks). These two alternatives were essentially the same alternative except for the optional setbacks. The setbacks can be evaluated as standalone additions to the combined alternative. This new alternative is titled "Fix in Place Feather River, Sutter Bypass, and Wadsworth Canal with Select Setbacks for Ecosystem Restoration." A map of this alternative is provided as Plate 17. The team also recommended that Alternative 4.1 (Setbacks with Ecosystem Restoration) be eliminated from further evaluation because the additional cost of this alternative compared to combined Alternatives 3.1 and 3.2

exceeds the additional restoration benefits and it has little probability of implementation. The ecosystem benefits from setbacks can be evaluated as standalone additions to the alternatives that are retained for further evaluation.

Finally, it was determined that the team should evaluate an optional measure that would provide FRM to the area south of the community of Sutter between the Sutter Bypass levee and Wadsworth Canal Levee. This was recommended to address completeness within the study area.

A matrix with the array of alternatives to be carried forward and measures associated with each of these alternatives is included in Table 8. This array will be evaluated in further detail as the team progresses toward selection of the Tentatively Selected Plan (TSP).

Table 8. Refined Alternatives to be Evaluated in Further Detail

ID	Management Measure	Primarily Nonstructural with Minimal Levee Improvement Reaches	Yuba City Ring Levee	Little "J" Levee	Fix in Place Feather River Thermalito to Star Bend	Fix in Place Feather River[1], Sutter Bypass[2], and Wadsworth Canal[3] with select setbacks for ecosystem restoration
S4	Yuba City Ring Levee		X			
S5	Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend	X SBFCA segment 4 and 5 only (Sunset Weir to Shanghai Bend)		X	X	X
S6	Southern Portion of J-Levee			X		
S7	Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee				X Shanghai Bend to Star Bend	X
S9	Sutter Bypass Setback Levee					O
S10	Northern Feather River Setback Levee			O	O	O
S11	Sutter Bypass and Feather River Confluence Setback Levee					O
S12	Star Bend Setback Levee	O	O	O	O	O
S13	Oroville DFG Wildlife Management Area –Degrade Land Surface and Restore Wetlands	O	O	O	O	O
S15	Southern Relief Structure	O	O	O	O	O
S23	Sunset Weir Modification	O		O		O
S26	Managed overtopping (levee superiority) on Feather River and Sutter Bypass.	O		O	O	O
S27	Improve upstream fish passage in Sutter Bypass. (Remove fish passage barriers). Dependent on					O

	S9					
S28	Sutter Bypass Sediment Removal			O	O	O
NS1	Relocate structures and critical infrastructure in floodplain.	O	O	O	O	O
NS2	Floodproof at isolated locations.	O	O	O	O	O
NS3	Elevate structures and transportation infrastructure	O	O	O	O	O
NS4	Establish flood-resistant housing	O	O	O	O	O
NS5	Secure large floatable objects	O	O	O	O	O
NS6	Flood-warning system	X	X	X	X	X
NS7	Evacuation plan	X	X	X	X	X
NS8	Construct ring levees at isolated locations	O	O	O	O	O
NS9	Floodfight pre-staging equipment and supply area	X	X	X	X	X
R1	Multi-Use Trails	O	O	O	O	O
R2	Bicycle Trails	O	O	O	O	O
R3	Equestrian Trails	O	O	O	O	O
R4	Day Use Area	O	O	O	O	O
R5	River Access	O	O	O	O	O
R6	Scenic Overlook	O	O	O	O	O
R7	Recreational parkway	O	O	O	O	O

X: Included in alternative
O: Optional to alternative

1 Feather River West Levee from Thermalito to Sutter Bypass
2 Sutter Bypass East Levee, Wadsworth Canal to Feather River
3 Wadsworth Canal East Levee, East Interceptor to Sutter Bypass

6.0 COMPARISON OF REFINED ALTERNATIVES

6.1 REFINED ARRAY OF ALTERNATIVES

Following is a summary of the refined array of alternatives that will evaluated in further detail as the team progresses toward selection of the TSP for In Progress Review (IPR) 4. The No Action Alternative is designated as Alternative SB-1.

6.1.1 Minimal Fix-in-Place plus Non-Structural SB-2

A map of this alternative including estimated residual floodplains is provided as Plate 13. This alternative consists of fixing-in-place the Feather River levees from Sunset Weir up- to and including a Star Bend set back (partial S5 and S7 measures). This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Other non-structural measures include relocation of structures and critical infrastructure in the floodplain; flood proofing at isolated locations; elevating structures and transportation infrastructure; establishing flood-resistant housing, securing large floatable objects, constructing ring levees at isolated locations, and incorporating a southern relief structure.

- Construct a Southern Relief Structure.

- Department of Fish and Game Wildlife Management Area (DFGWMA) Re-contour Floodplain.

- Sunset Weir Modification.

6.1.2 Yuba City Ring Levee Alternative SB-3

A map of this alternative including estimated residual floodplains is provided as Plate 14. This alternative consists of a ring levee around Yuba City. The height of the Yuba City ring levee was estimated based on the 0.5% (1/200) ACE levee breach floodplain and additional height to provide 90% reliability. The eastern flank of the Yuba City ring levee would utilize the existing Feather River levee. The ring levee was assumed to require two new pump stations to address interior drainage. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Construct a Star Bend setback levee.

- DFGWMA Re-contour Floodplain.

- Construct a Southern Relief Structure

6.1.3 Little J Levee Alternative SB-4

A map of this alternative including estimated residual floodplains is provided as Plate 15. This alternative includes fixing-in-place in place Feather River levees from Thermalito to Shanghai Bend (partial S5 measure), and constructing a new levee to the south and west of Yuba City (Little J). The "J" levee was assumed to require two new pump stations to address interior drainage. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Construct a Star Bend setback.

- Northern Feather River Setback.

- DFGWMA Re-contour Floodplain.

- Sunset Weir Modification.

- Construct a Southern Relief Structure.

6.1.4 Fix-In-Place Feather River, Thermalito to Star Bend Alternative SB-5

A map of this alternative including estimated residual floodplains is provided as Plate 16. This alternative consists of fixing- in -place Feather River levees from Thermalito up-to and including a Star Bend set back (partial S5 & S7 measures). This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Construct a Star Bend setback levee in lieu of a fix-in-place.
- Northern Feather River Setback.
- DFGWMA Re-contour Floodplain.
- Construct a Southern Relief Structure

6.1.5 Fix-In-Place Feather River, Sutter Bypass, and Wadsworth Canal Alternative SB-6

A map of this alternative including estimated residual floodplains is provided as Plate 17. This alternative consists of fixing –in- place the Feather River levees from Thermalito to the confluence with the Sutter Bypass, and fixing-in-place the east levees of the Sutter Bypass (partial S5 & S7 measures). Levees along the south side of Wadsworth Canal would also be fixed-in-place. This alternative also includes a Star Bend setback. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Construct a new setback levee at the Sutter Bypass and Northern Feather River confluence.
- DFGWMA Re-contour Floodplain.
- Sunset Weir Modification.
- Improve Fish Passage- dependant on a Sutter Bypass setback.
- Construct a Southern Relief Structure.

7.0 DRAFT ARRAY OF ALTERNATIVES

Further refinement and evaluation of the of the refined array of alternatives led to the addition of two additional alternatives identified as SB-7 and SB-8 that further reduced flood risk and addresses residual risk in terms of life safety. The alternative descriptions are as follows:

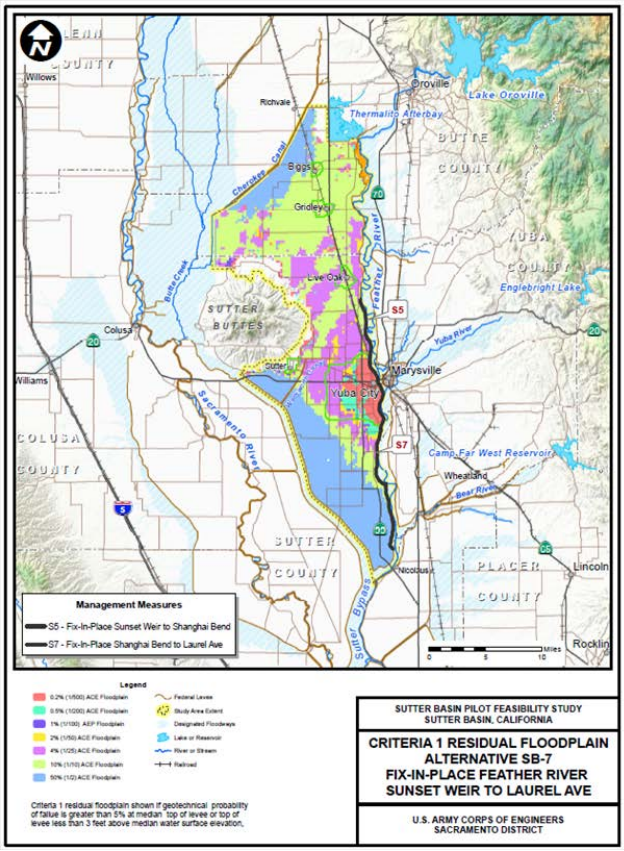

Plate 18: Alternative SB-7

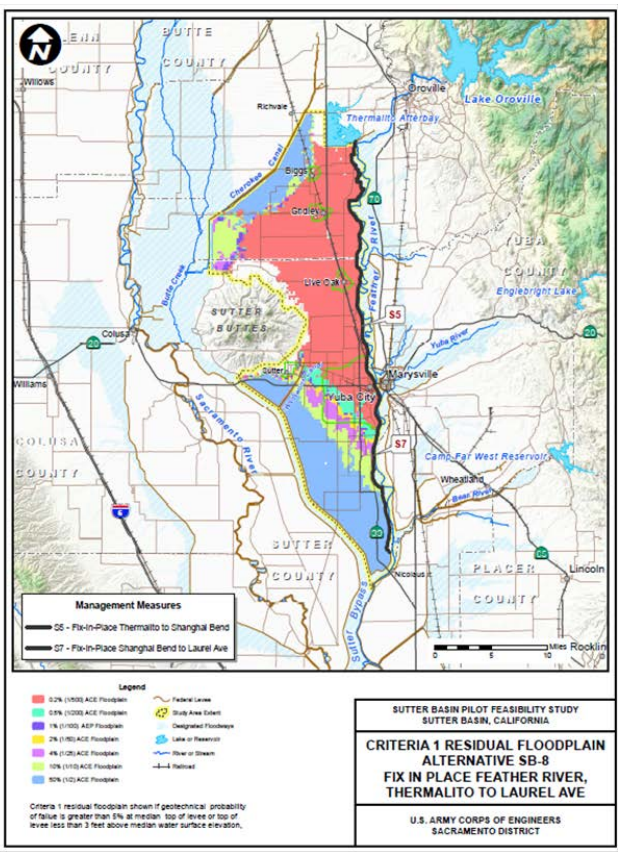

Plate 19: Alternative SB-8

Alternative SB-7: Fix-in-Place Feather River Levees, Sunset Weir to Laurel Avenue

This alternative includes SB-2 and extends Feather River fix-in-place levee improvements south of Yuba City to Laurel Ave. Reduction of flood risk includes SB-2 and additional flood risk reduction in the Yuba City southeastern areas. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Alternative SB-8: Fix-in-Place Feather River Levees, Thermalito Afterbay to Laurel Avenue

This alternative is inclusive of SB-7 and extends Feather River levee improvements north to Thermalito. Reduction in flood risk includes all of SB-7 and provides extensive flood risk reduction in the northern areas and communities of the Sutter Basin which includes the towns of Live Oak, Gridley, and Biggs. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

These final eight alternatives were further refined and evaluated as the Draft Array of Alternatives:

Alternative SB-1: No Action Alternative
Alternative SB-2: Minimal Fix-in-place Feather River Levees, Sunset Weir to Star Bend
Alternative SB-3: Yuba City Ring Levee
Alternative SB-4: Little "J" Levee
Alternative SB-5: Fix in Place Feather River Levees, Thermalito Afterbay to Star Bend
Alternative SB-6: Fix-in-Place Feather River Levees, Sutter Bypass, and Wadsworth Canal
Alternative SB-7: Fix-in-Place Feather River Levees, Sunset Weir to Laurel Avenue
Alternative SB-8: Fix-in-Place Feather River Levees, Thermalito Afterbay to Laurel Avenue

The final array of alternative process from this draft array are described in Decision Point 2 Report Summary document and Draft Report, Chapter that leads to the Tentatively Selected Plan.

8.0 REFERENCES

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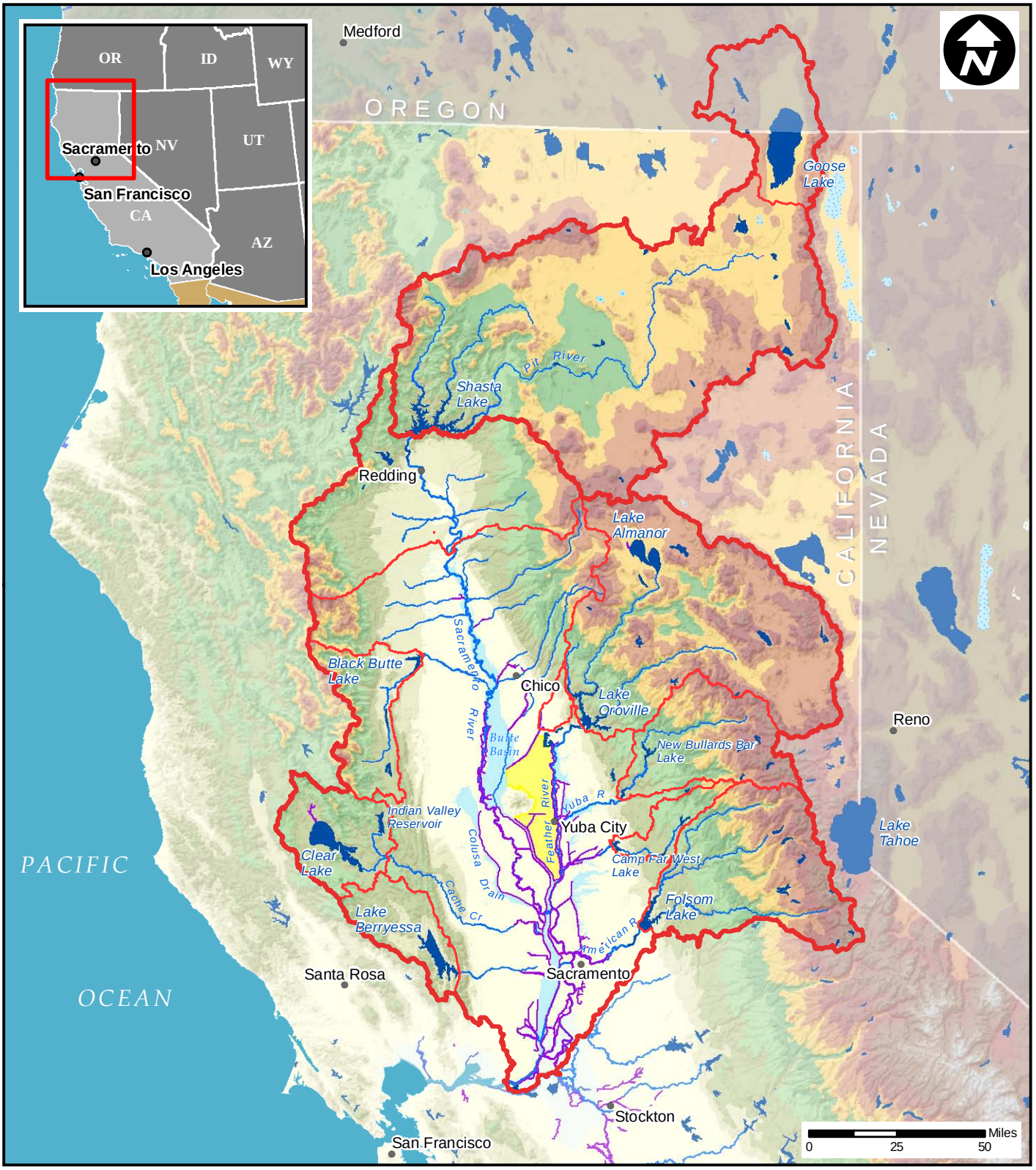
Sutter Basin Pilot Feasibility Study
Progress #1 Document:
Without Project and Alternative Development

Plates



Legend

- Study Area Extent
- Sacramento Basin
- Watershed Boundaries
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levees
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

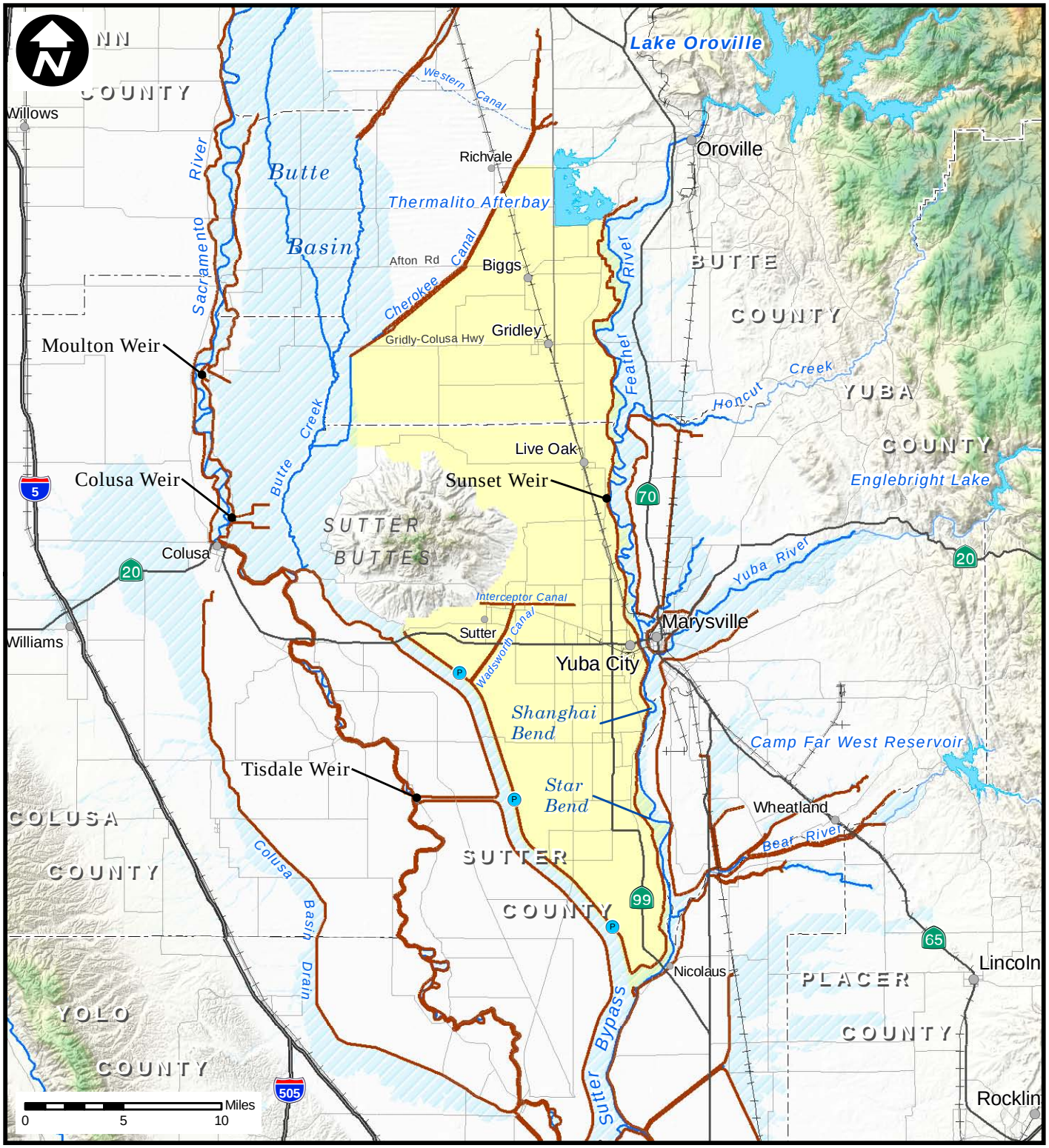
PROGRESS DOCUMENT #1
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 1



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- Pump Station
- Highway
- Major Road
- Railroad
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

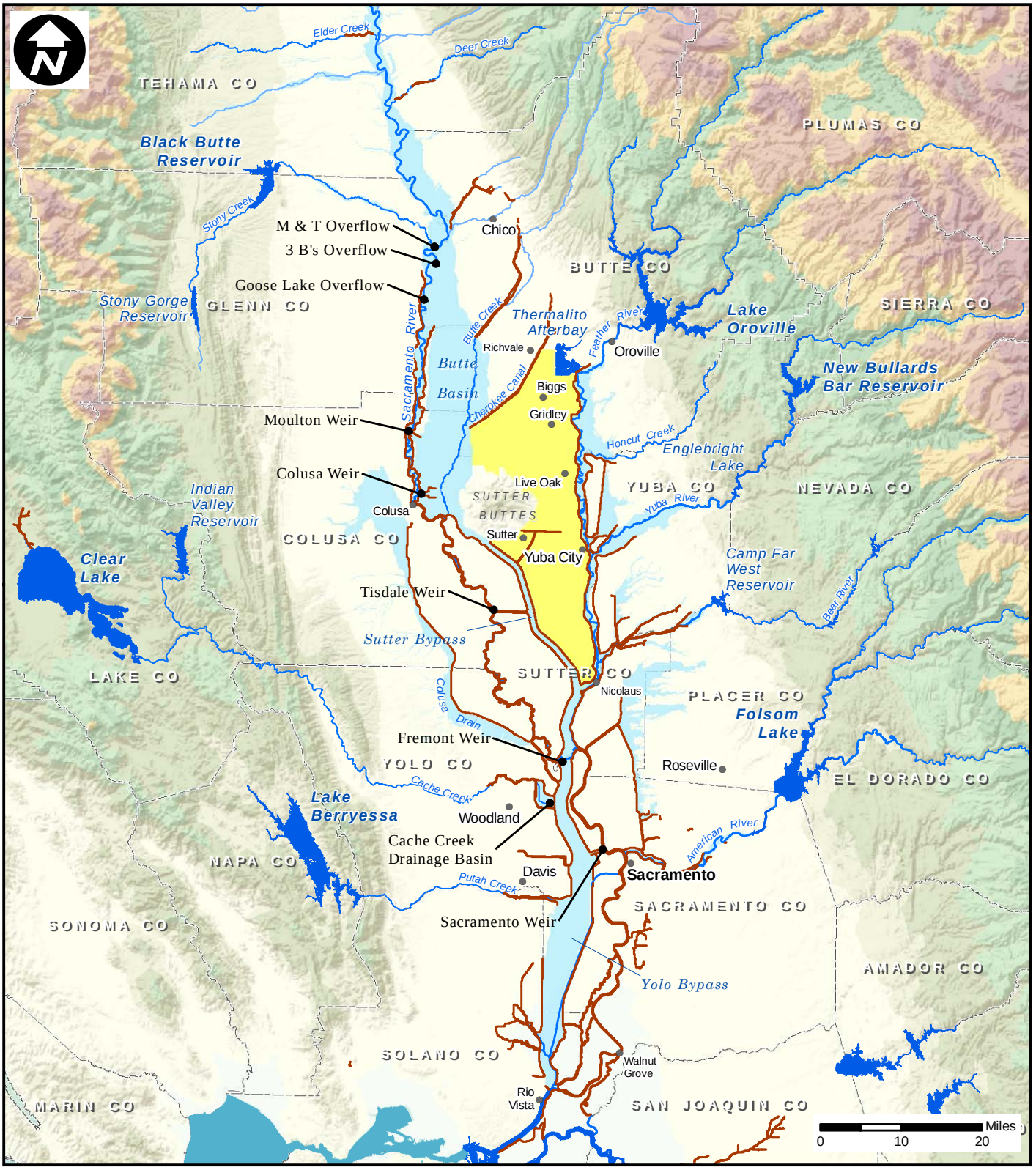
PROGRESS DOCUMENT #1
STUDY AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 2



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

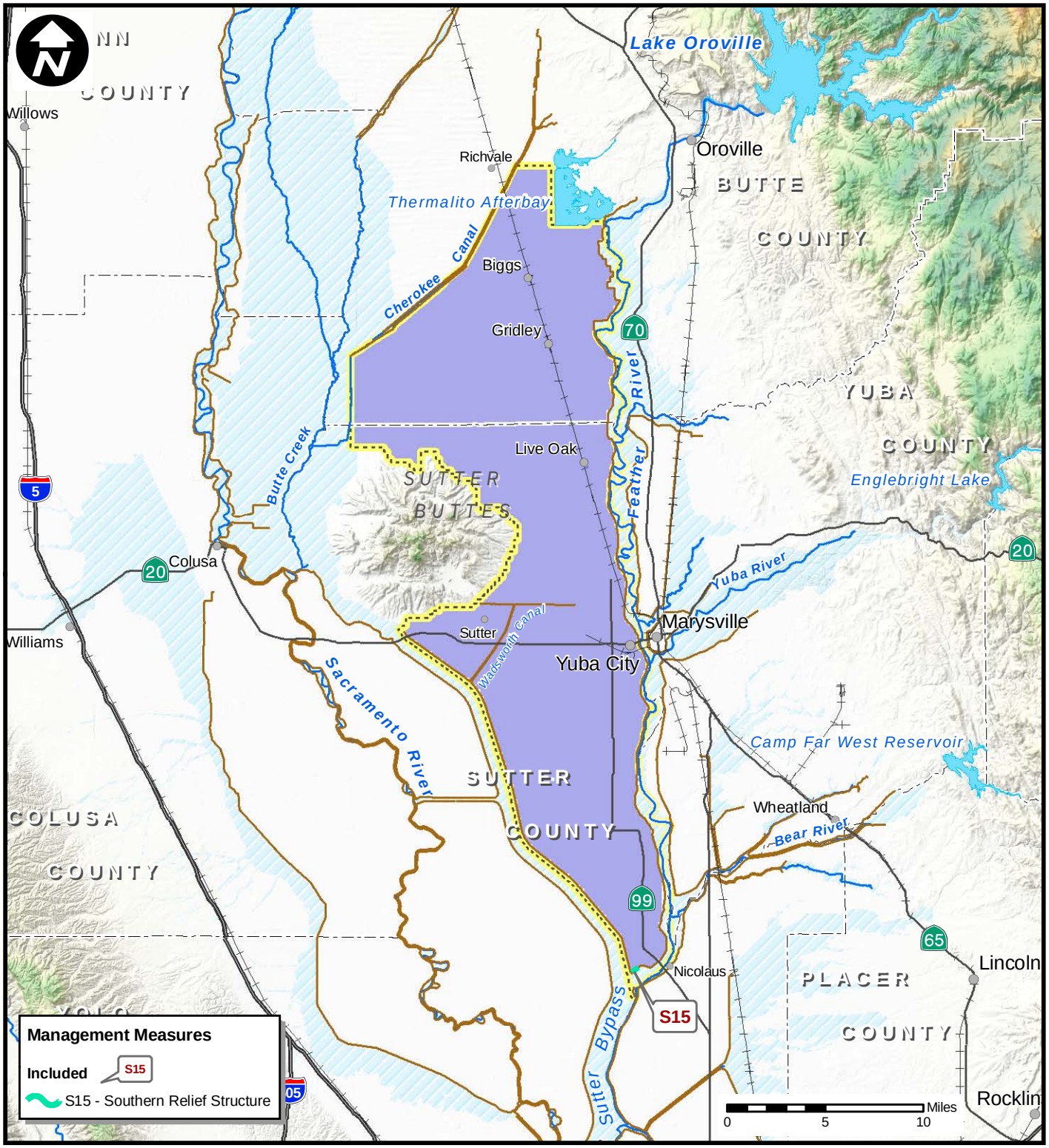
PROGRESS DOCUMENT #1
SACRAMENTO RIVER
FLOOD CONTROL PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 3



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 1.1

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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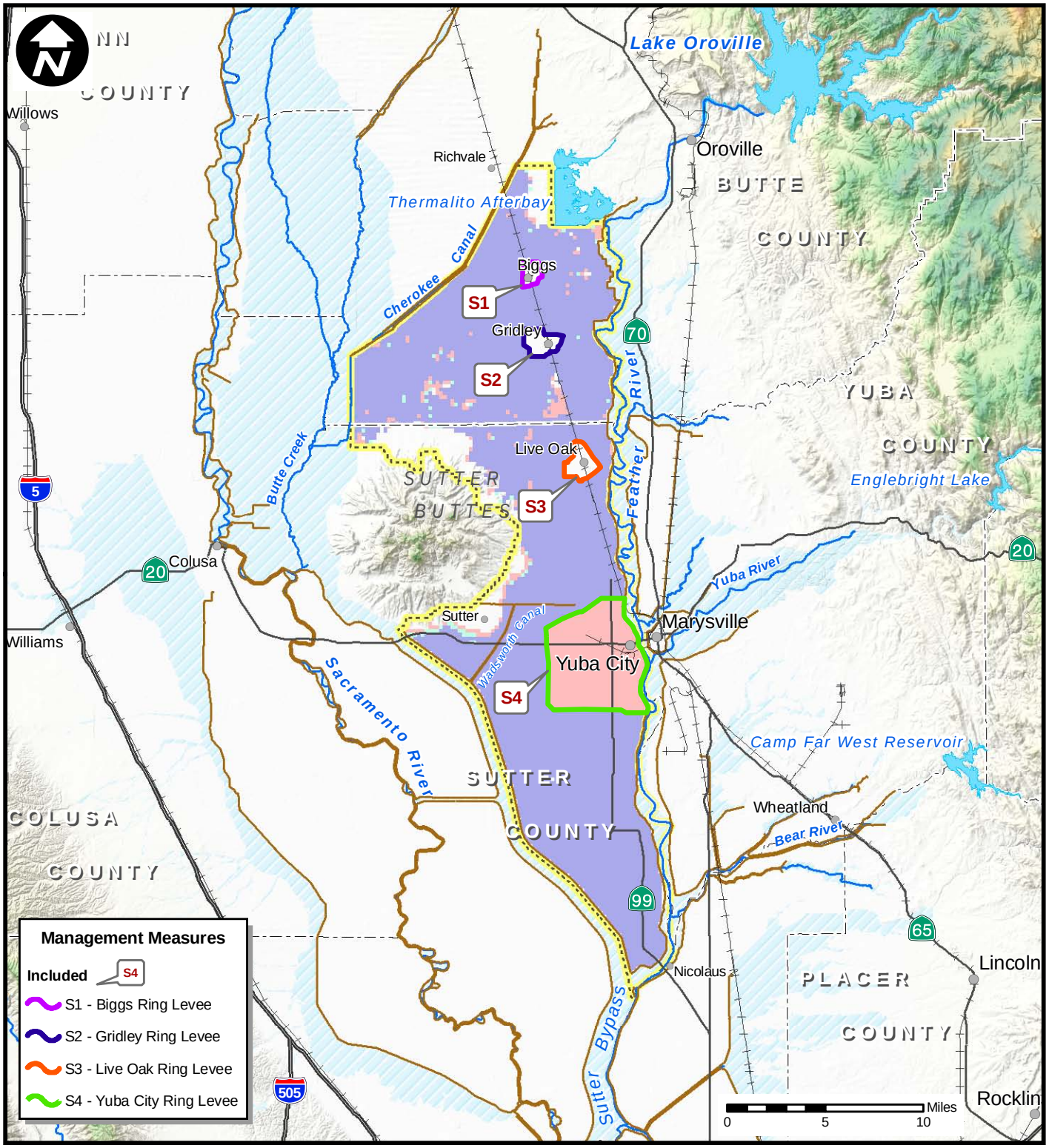
PLATE 4



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.1

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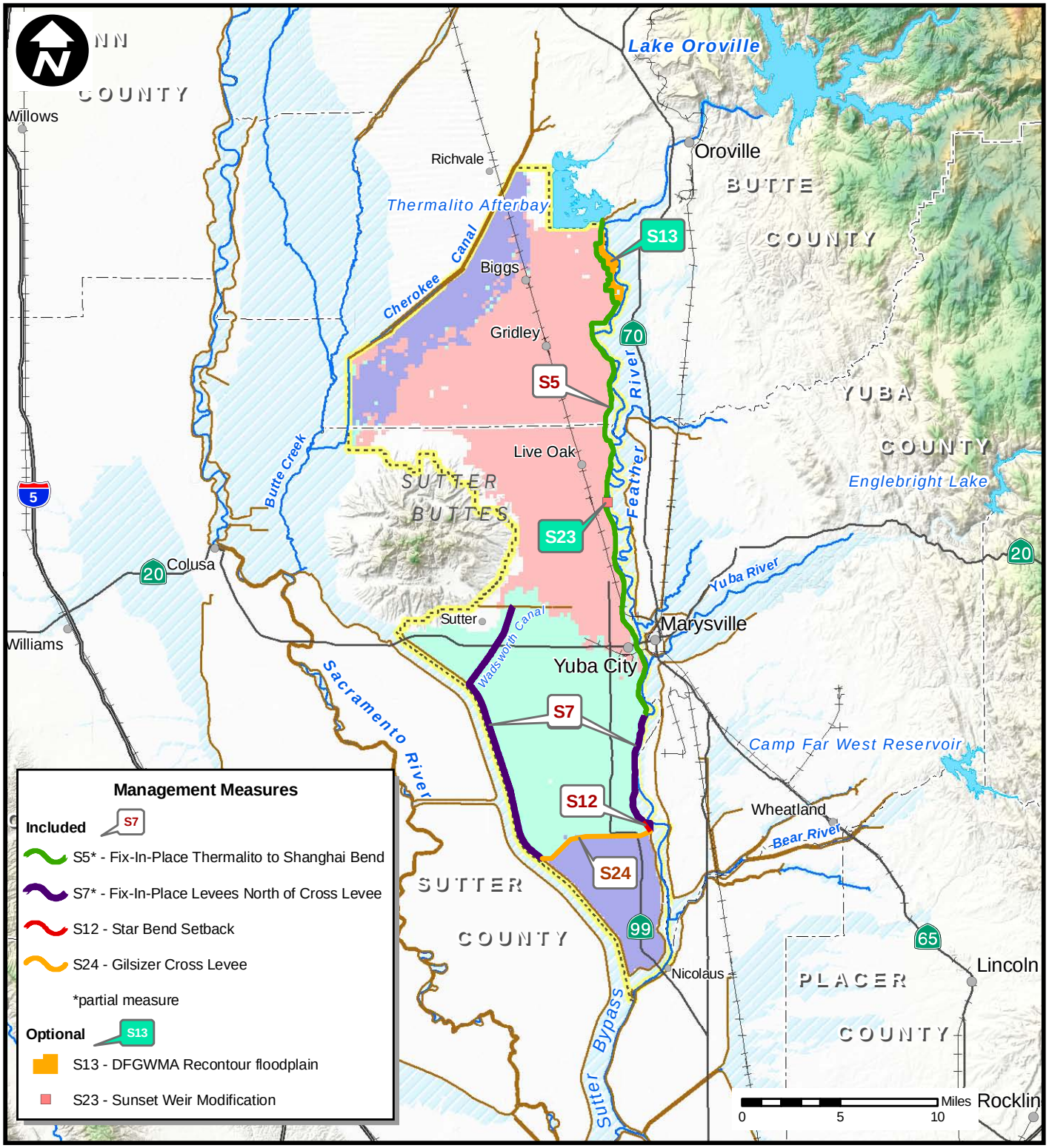
PLATE 5



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.2

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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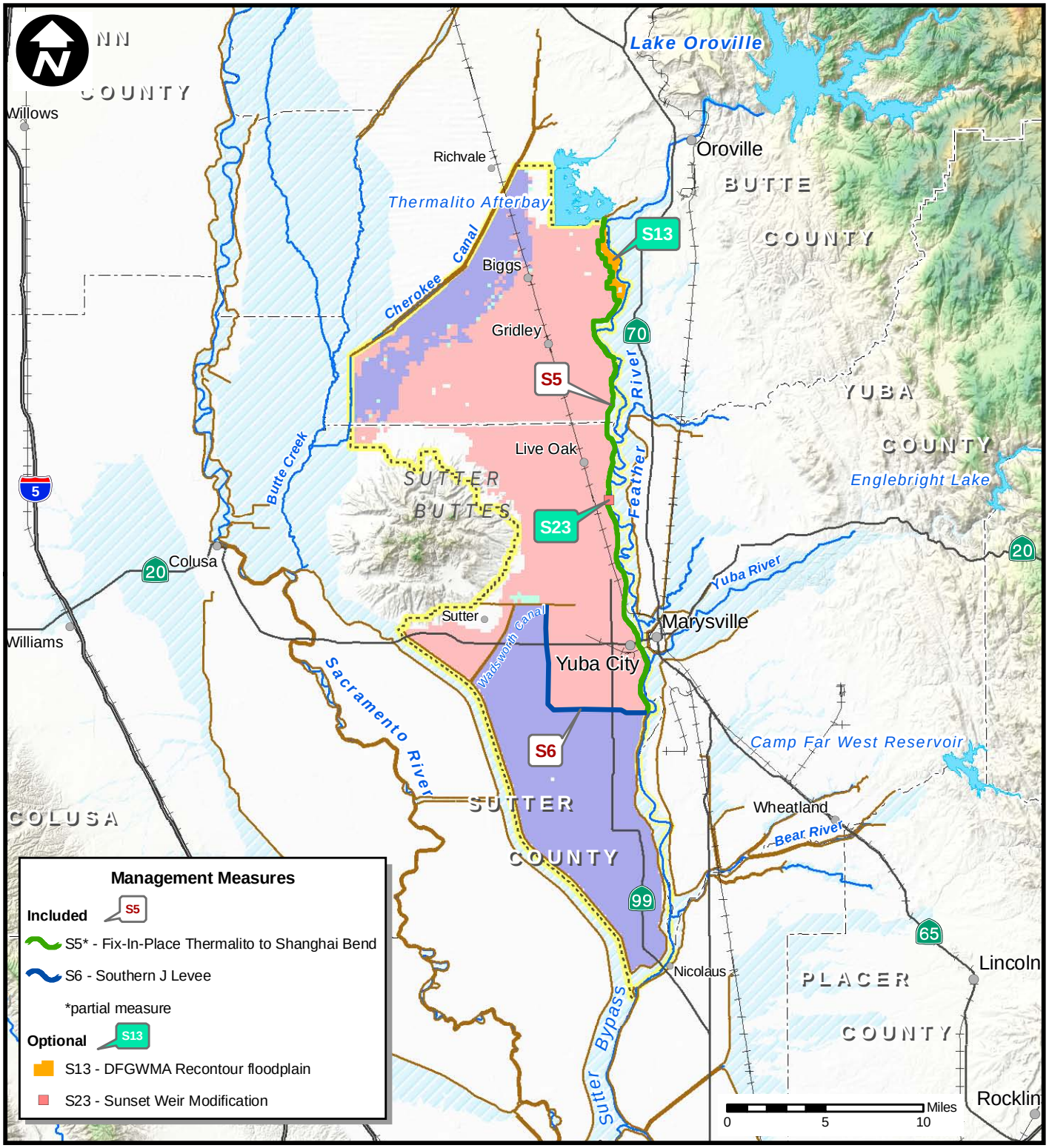
PLATE 6



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

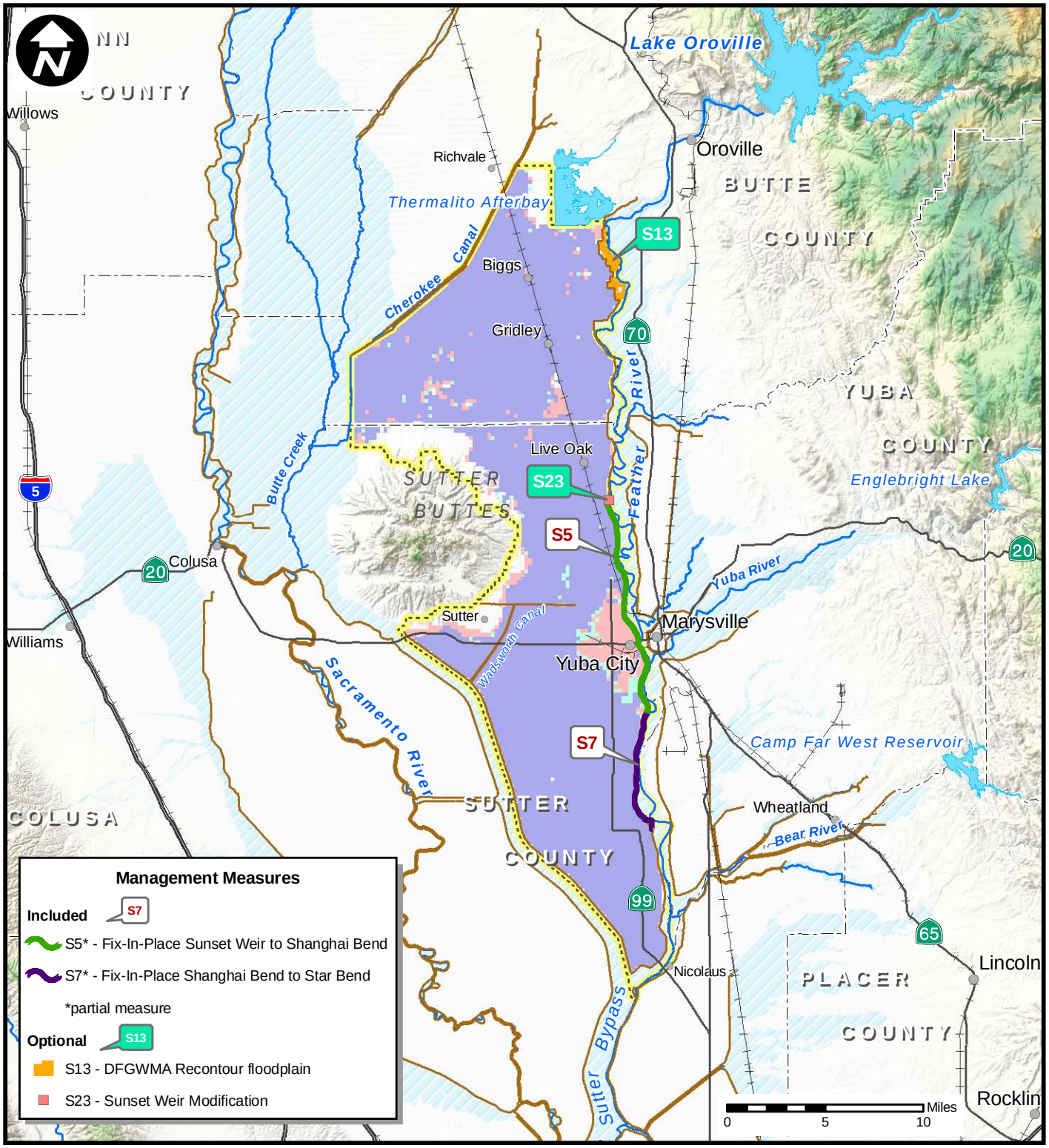
PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.3

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 7



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

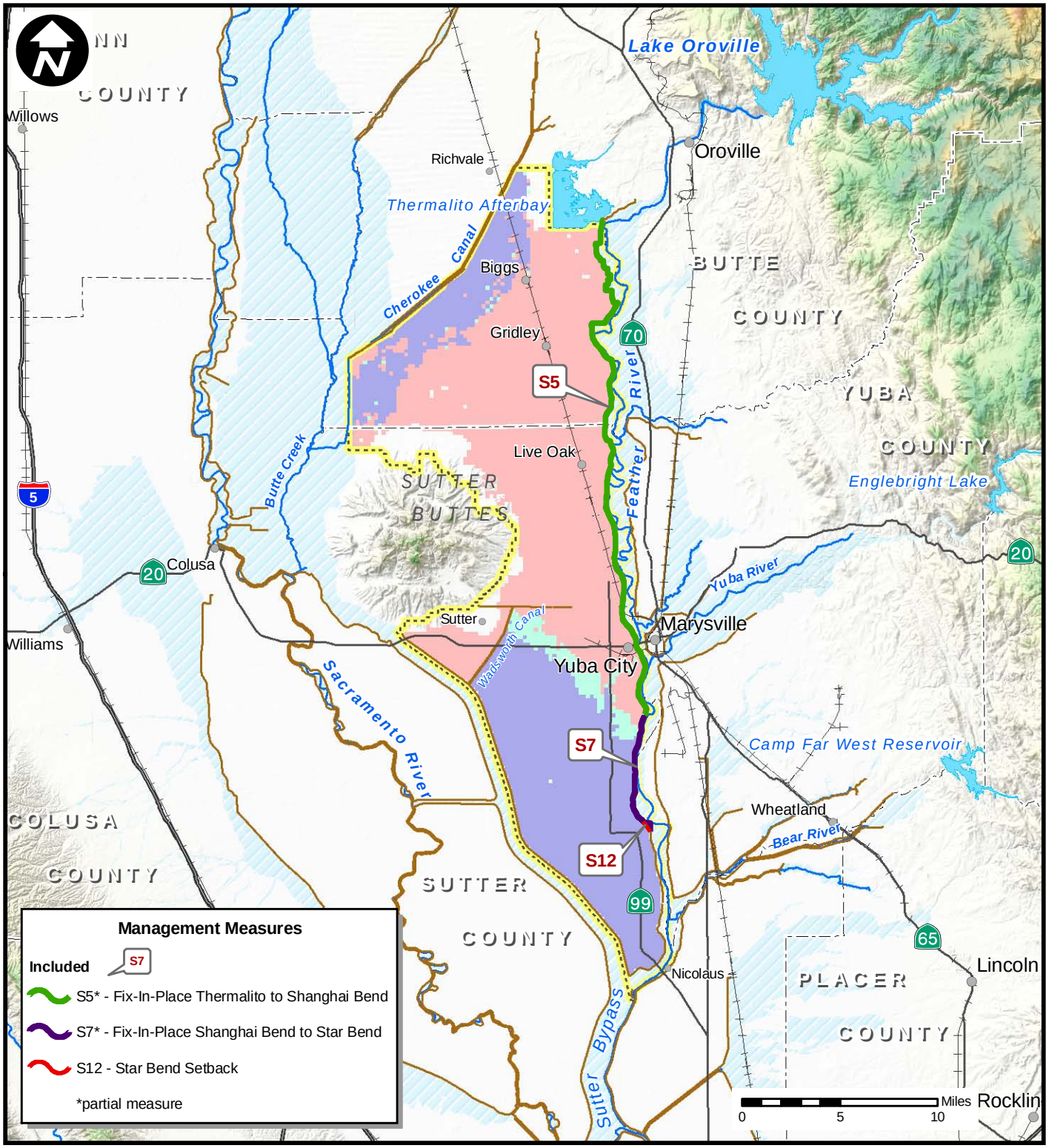
PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.4

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 8



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

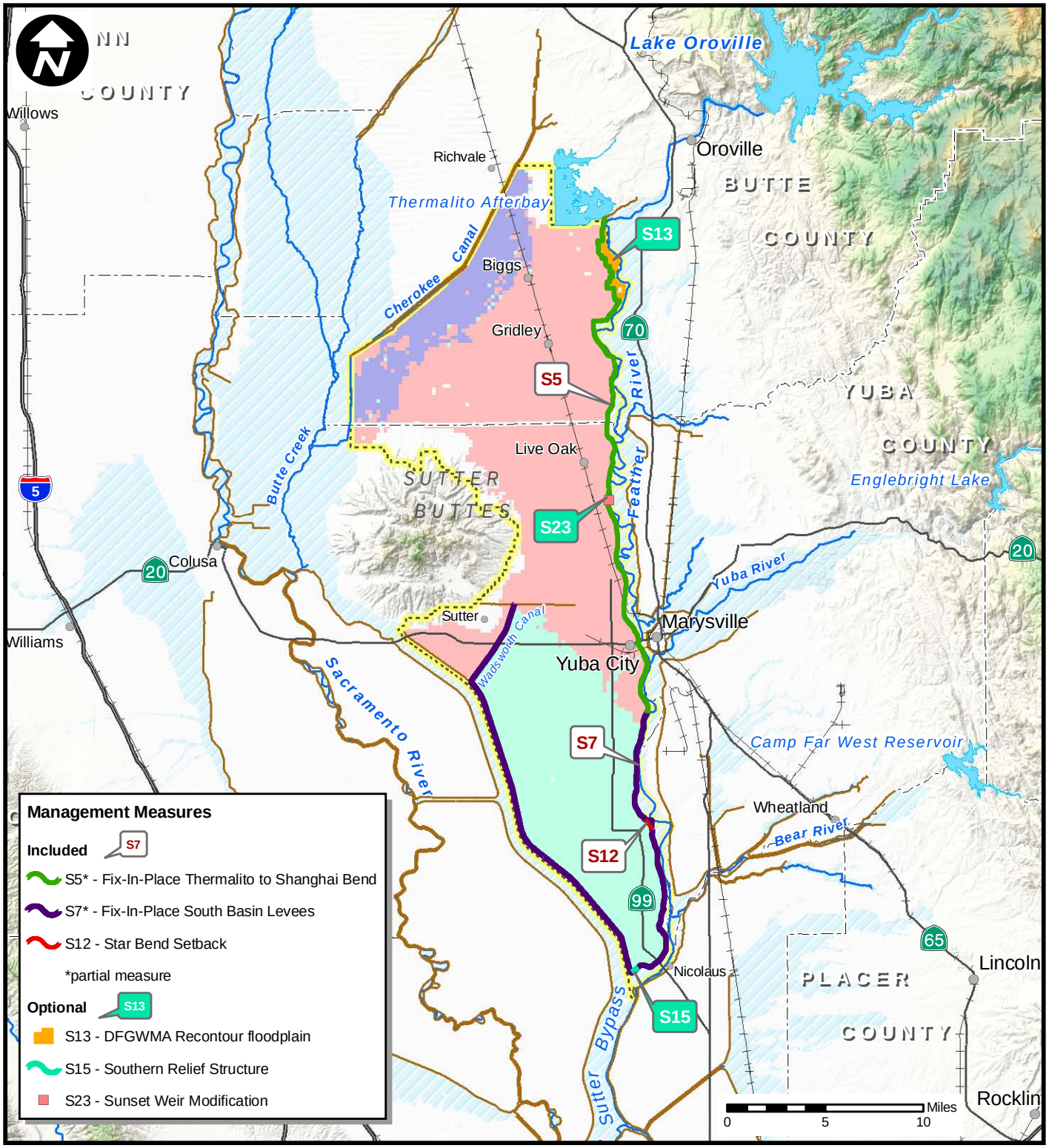
PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.5

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 9



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

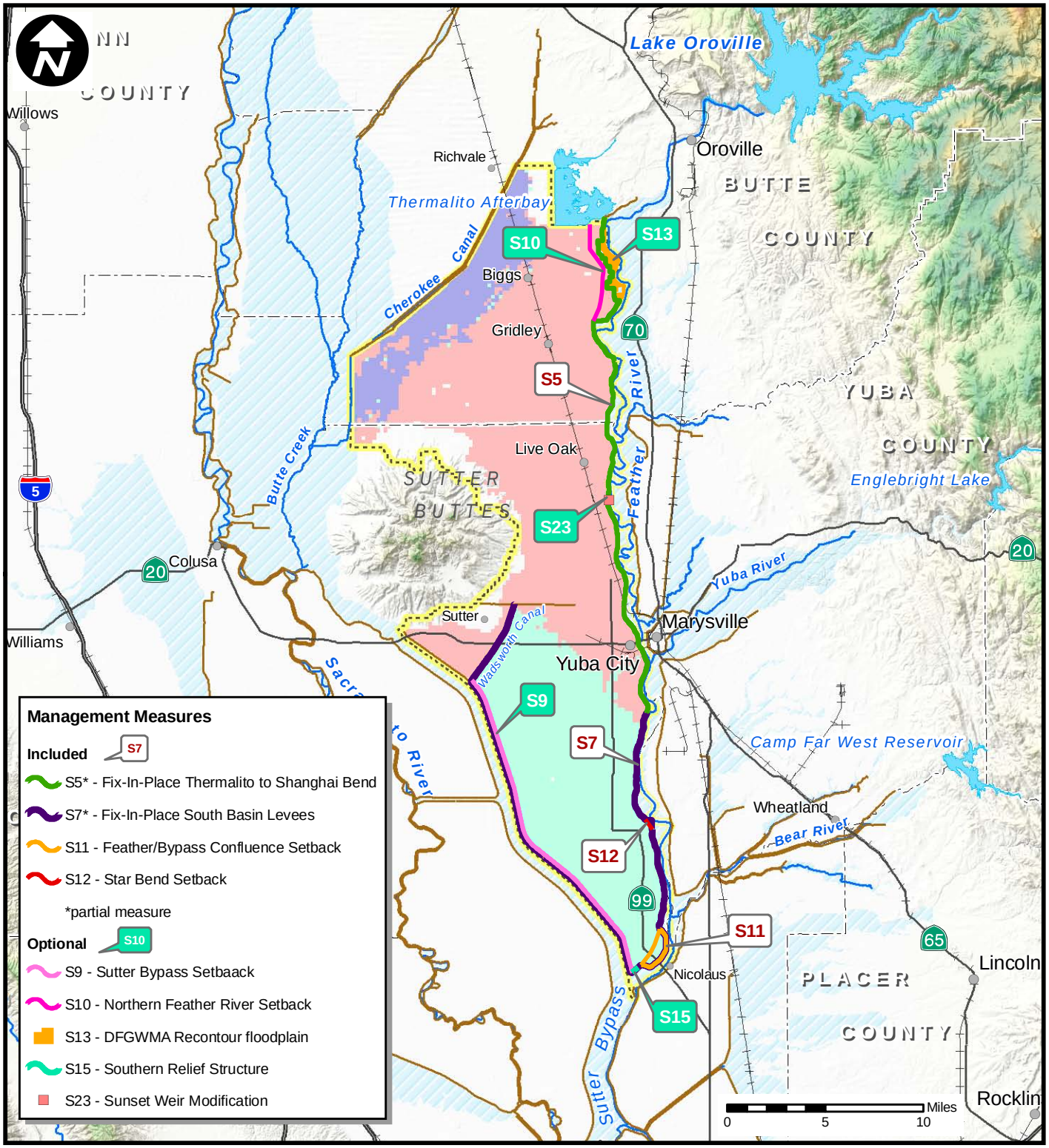
PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 3.1

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 10



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

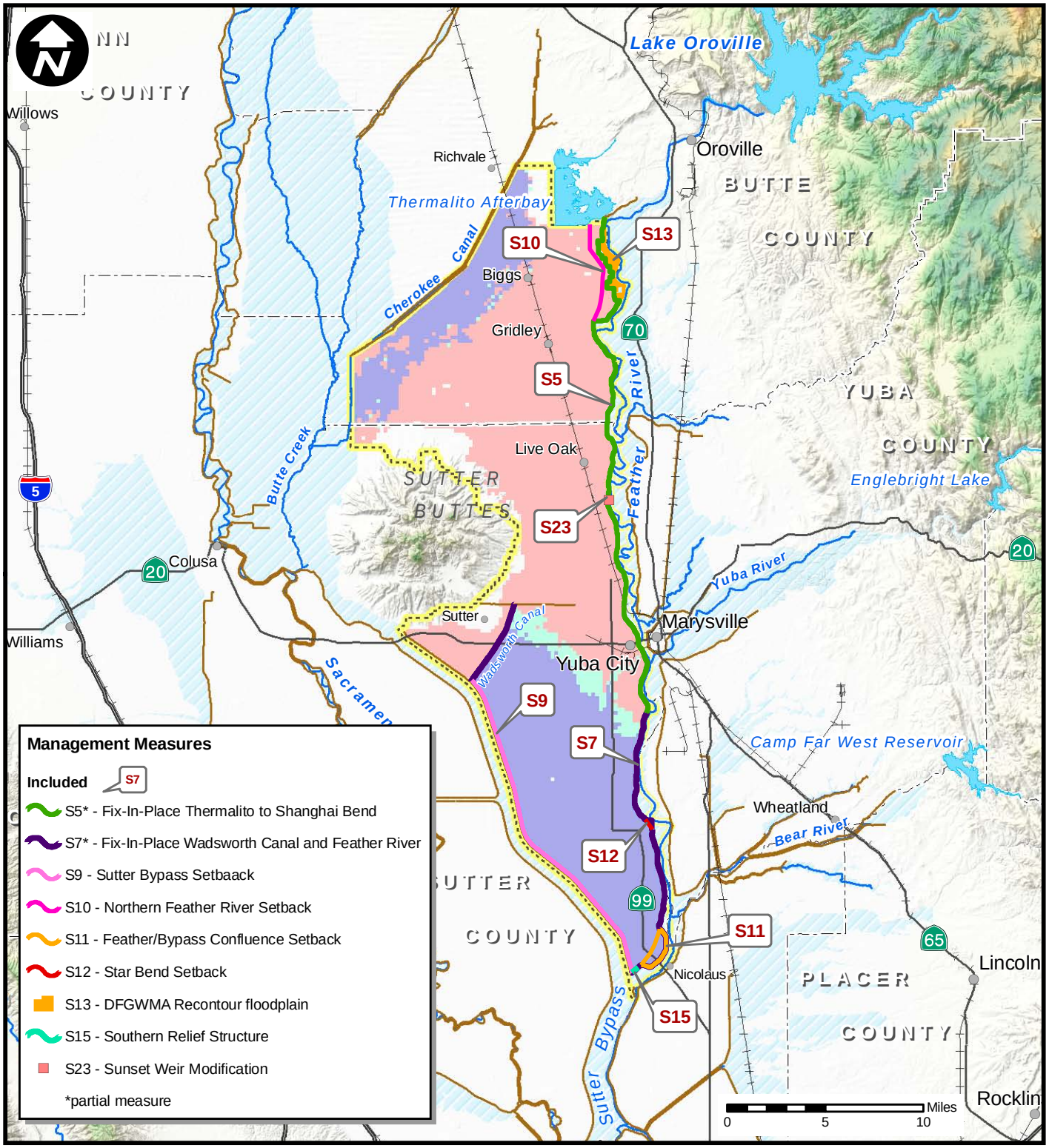
PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 3.2

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 11



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

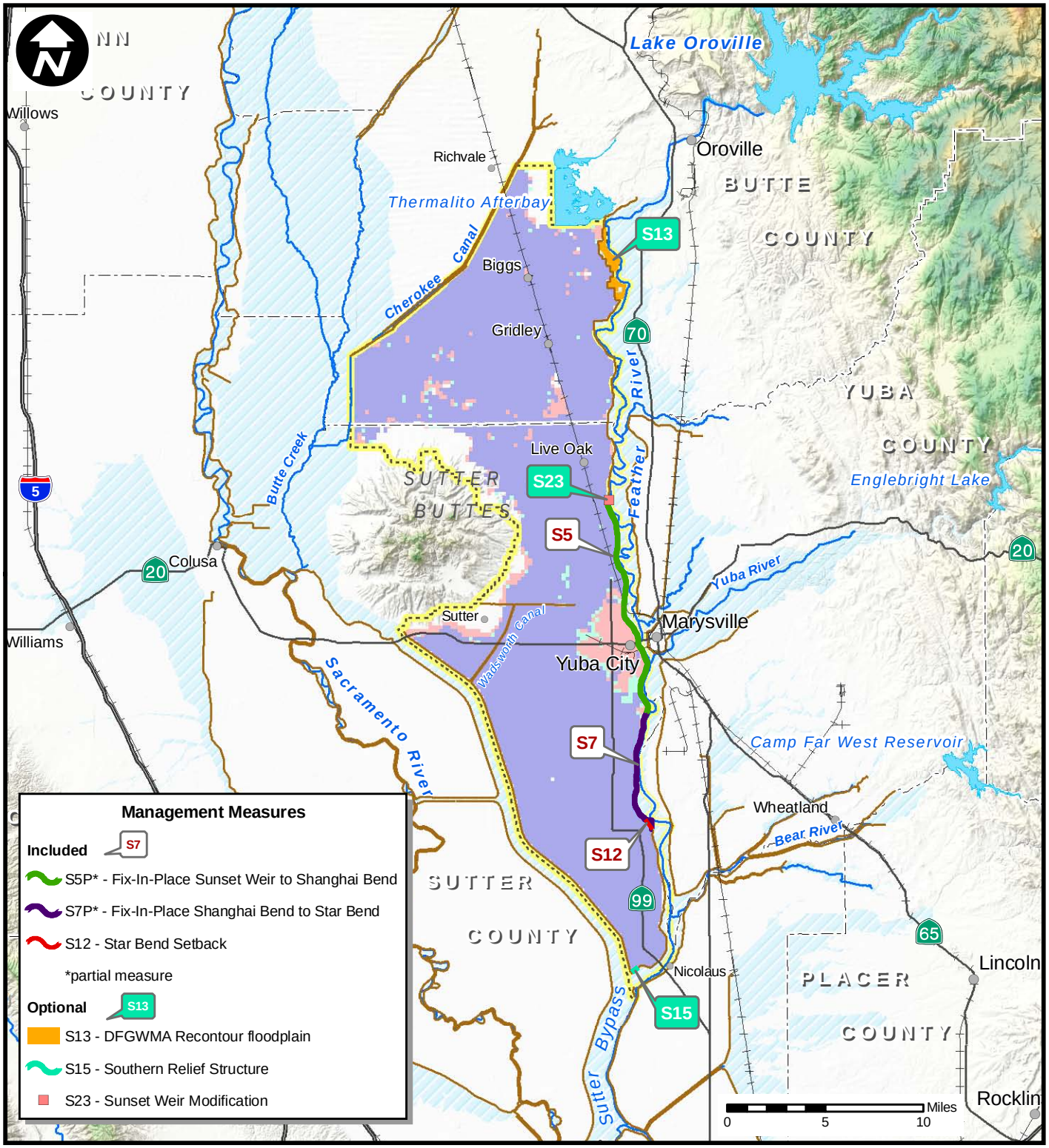
PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 4.1

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 12



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

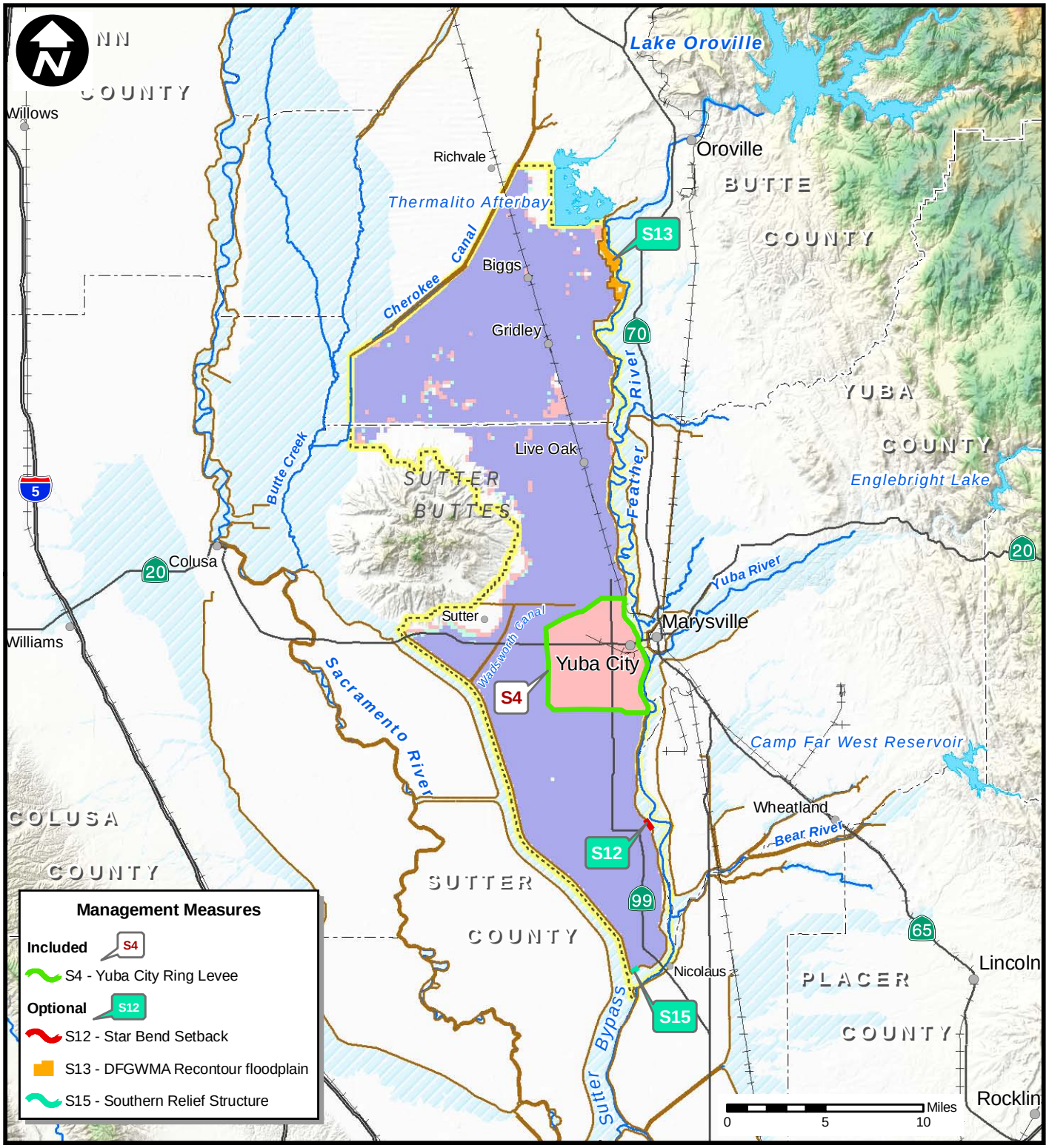
PROGRESS DOCUMENT #1
ALTERNATIVE SB-2
MINIMAL FIX-IN-PLACE
PLUS NONSTRUCTURAL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 13



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

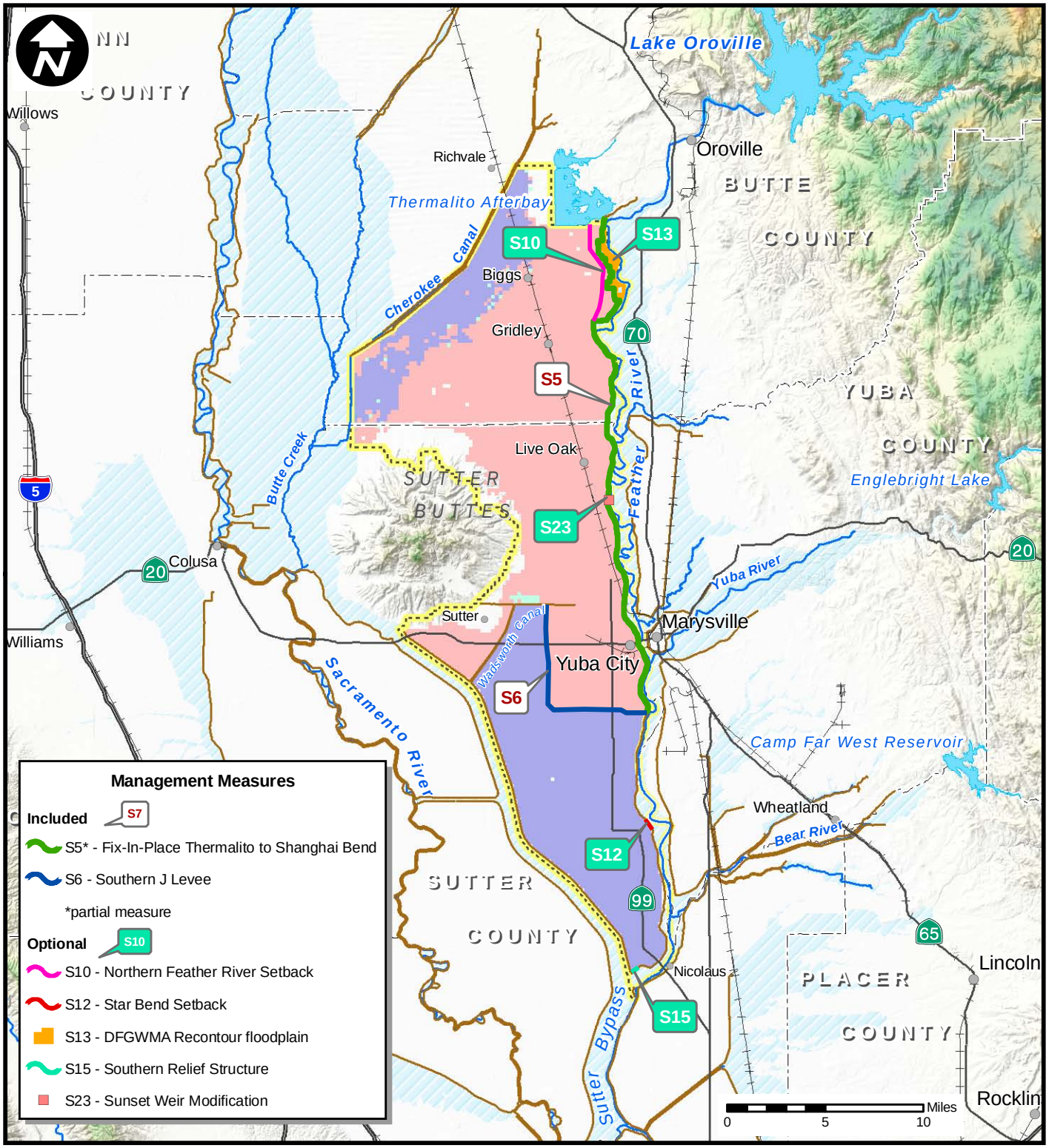
PROGRESS DOCUMENT #1
ALTERNATIVE SB-3
YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 14



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

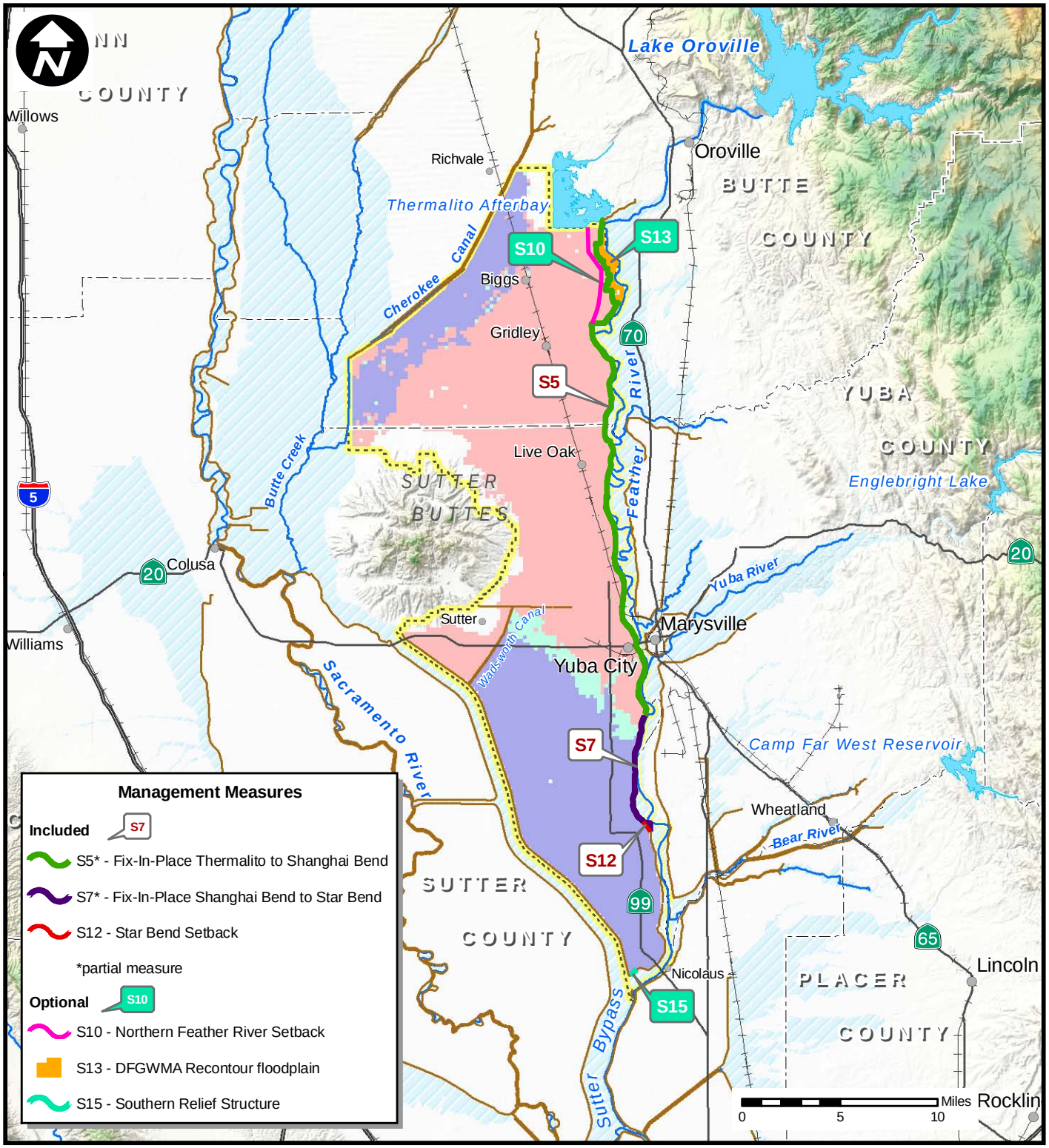
PROGRESS DOCUMENT #1
ALTERNATIVE SB-4
LITTLE "J" LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 15



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual models*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

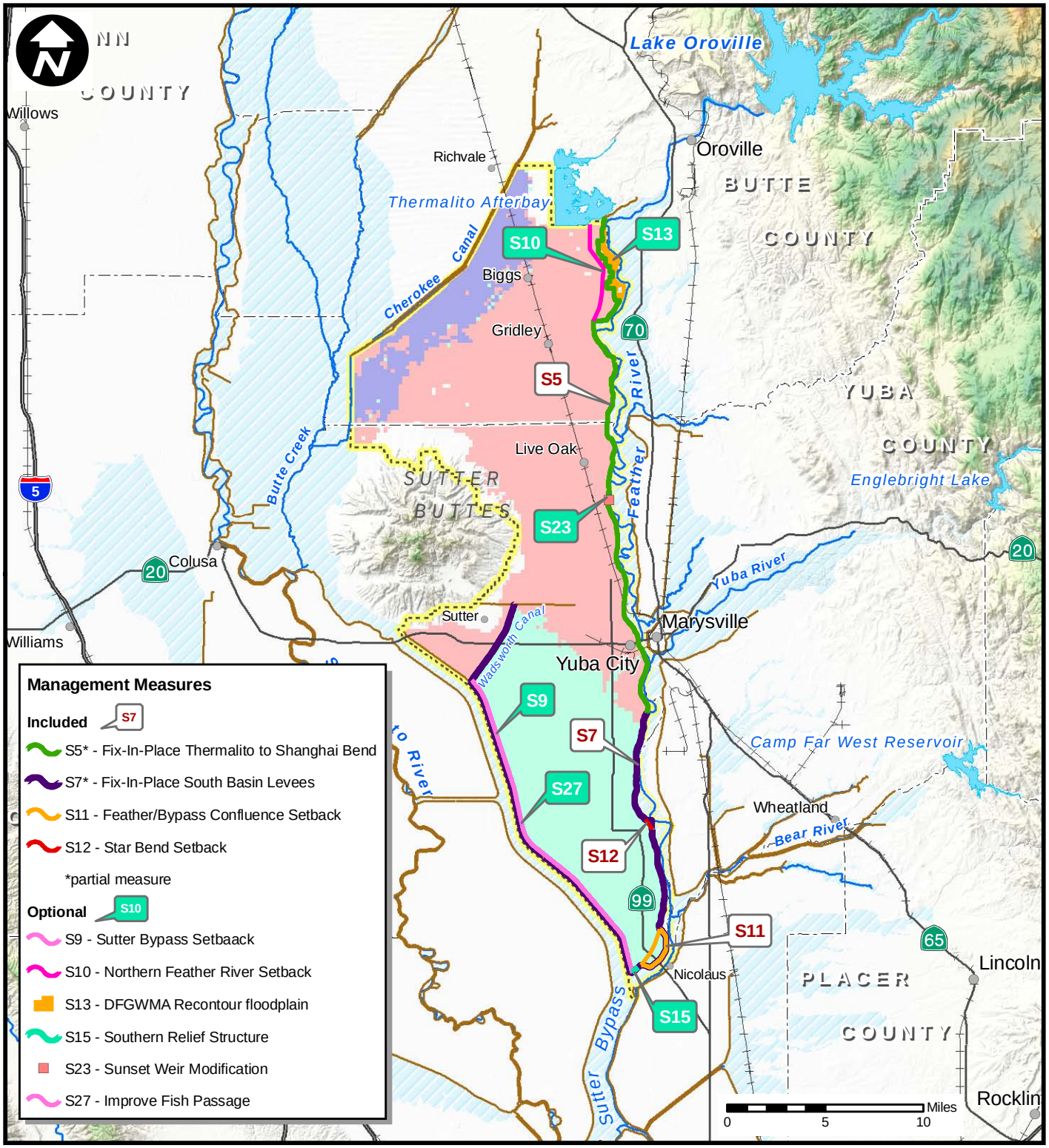
PROGRESS DOCUMENT #1
ALTERNATIVE SB-5
FIX IN PLACE FEATHER RIVER, THERMALITO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 16



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
ALTERNATIVE SB-6
FIX IN PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH

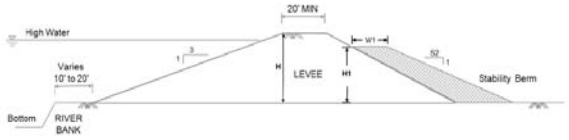
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

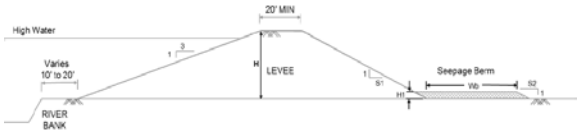
PLATE 17

Stability Berm Element

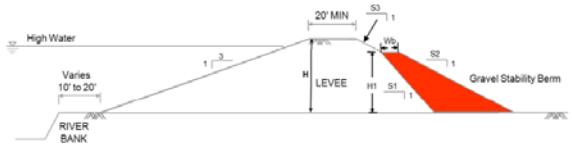


Stability Berm with Relief Wells Element

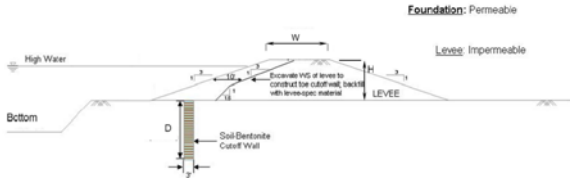
Seepage Berm Element



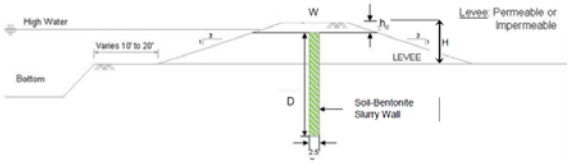
Gravel Stability Berm Element



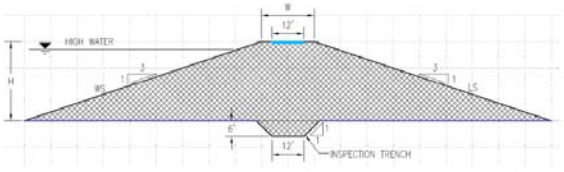
Waterside Soil-Bentonite Slurry Cutoff Wall Element



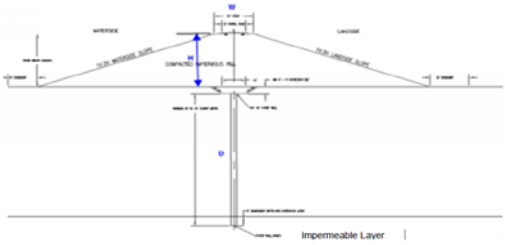
Centerline Soil-Bentonite Slurry Cutoff Wall Element



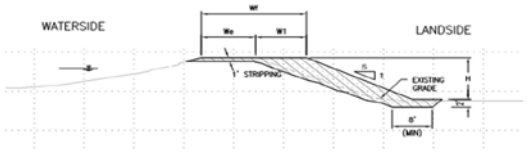
New Levee Element



New Levee with Centerline Soil-Bentonite Cutoff Wall Element



Levee Crest Widening Element



Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1

LEVEE DESIGN TEMPLATES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT